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**REMEDIAL ACTION
FIELD SAMPLING PLAN**

**SKINNER LANDFILL SITE
BUTLER COUNTY
WEST CHESTER, OHIO**

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FINAL
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Project Number 38335

LIST OF ACRONYMS

AMP	Air Monitoring Plan
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
BOD	Biochemical Oxygen Demand
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
Conrail	Consolidated Railroad Corporation
CP	Contingency Plan
CQAP	Construction Quality Assurance Plan
DNAPLs	Dense Non-Aqueous Phase Liquids
FS	Feasibility Study
FSP	Field Sampling Plan
GWDI	Groundwater Design Investigation
HASP	Health and Safety Plan
HCl	Hydrochloric Acid
HDPE	High Density Polyethylene
ID	Inner Diameter
LTPP	Long Term Performance Plan
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
OEPA	Ohio Environmental Protection Agency
OSHA	Occupational Safety & Health Administration
PCBs	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
PRP	Potentially Responsible Party
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
su	Standard Units
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	Spill Prevention Control and Countermeasure Plan
SVE	Soil Vapor Extraction
SVOCs	Semi-Volatile Organic Compounds
TAL	Target Analyte List
TCL	Target Compound List
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

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1.0 PROJECT DESCRIPTION

This document is the Remedial Action (RA) Field Sampling Plan (FSP) for the Skinner Landfill Superfund Site located in West Chester, Butler County, Ohio. This document addresses the requirements of the Remedial Design (RD) Statement of Work (SOW), Section II, B.3 that identifies a Final FSP will be submitted as part of the Pre-Final Design Document.

The RA FSP has been prepared pursuant to the requirements of the SOW of the Administrative Order on Consent (AOC) between the United States Environmental Protection Agency (U.S. EPA) and the Skinner Landfill Potentially Responsible Party (PRP) Group dated June 4, 1993. The selected RA components were based on the SOW and were modified based on the results of the RD Design Investigation. The RD Design Investigation was completed during the Fall of 1994 and the corresponding report is dated June 1, 1995. The RA components (as modified by the results of the RD Design Investigation) include the following:

- Institutional Controls;
- Engineered Landfill Cover;
- Groundwater Interception System (and sanitary sewer tie-in);
- Groundwater Monitoring; and
- Surface Water Monitoring.

1.1 Site Location and Description

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio near West Chester, Butler County, Ohio in Township 3, Section 22, Range 2. The site is located along Cincinnati-Dayton Road as shown in Figure 1. The site is bordered on the south by the East Fork of Mill Creek, on the north by wooded land, on the east by a Consolidated Railroad Corporation (Conrail) railroad right-of-way, and on the west by the Skinner Creek.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (MSL) in the northeast, to a low of 645 feet MSL near the confluence of the Skinner Creek and the East Fork of Mill Creek. Both Skinner Creek and the East Fork of Mill Creek are small, shallow streams. Both of these streams flow to the southwest from the site toward the main branch of Mill Creek. A third on-site stream, Dump Creek, borders the landfill on the east. Dump Creek is intermittent and flows south into the East Fork of Mill Creek. Three shallow ponds are also located on the site.

In general, the site is underlain by relatively thin glacial drift over interbedded shales and limestones of Ordovician age. The composition of the glacial drift ranges from intermixed silt, sand and gravel, to silty, sandy clays; and its thickness ranges from zero to over 40 ft on the site. The sand and gravel deposits comprise the hills and ridges and are encountered near the surface of the central portion of the site. The silts and clays usually occur as lenses in the sands and gravel or directly overlie bedrock.

1.2 Site History and Background

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to U.S. EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to U.S. EPA studies, the

buried waste lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA (OEPA) initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the OEPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the OEPA from accessing the site by claiming that nerve gas, mustard gas, and explosives were buried in the landfill. The OEPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and an U.S. Army records review performed in 1992 did not reveal any evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the U.S. EPA based on information obtained during a limited investigation of the site. The investigation indicated groundwater contamination had occurred as a result of the buried wastes. In 1986, a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water and soil, as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Baseline Risk Assessment and Feasibility Study (FS) were completed in 1992.

The Phase II Remedial Investigation revealed that the most contaminated media at the site is the soil from the buried waste lagoon. Lower levels of contamination were also found in soils on other portions of the site and in the groundwater, and very low levels were found in the sediments of the Mill Creek, the Skinner Creek, the Duck Pond, and the Diving Pond. Migration of the landfill constituents has been limited, and the Phase II Remedial Investigation concluded that there had been no off-site migration of landfill constituents via groundwater flow.

In the ROD, U.S. EPA selected a remedy for the site consisting of multi-media capping of the landfill and the buried waste lagoon, and interception and treatment of the contaminated groundwater. The ROD also required an investigation be conducted to determine the feasibility for soil vapor extraction (SVE) in the granular soil adjacent to the buried lagoon.

The RD Design Investigation performed in 1994 was implemented to collect data required to assess the feasibility of the SVE and to design the multi-media cover and the groundwater extraction and treatment systems. Based on the results of the RD Design Investigation, necessary data was collected to design the U.S. EPA selected remedies. The following results were developed based on the RD Design Investigation:

- Groundwater collected during previous investigations and the Groundwater Design Investigation (GWDI) indicated groundwater has been impacted at the Skinner Landfill Site and the current groundwater conditions are similar to those used to develop the ROD;
- Trigger levels used in the Administrative Order to define groundwater contamination were modified based on the methods described in the RD SOW;
- A combination of interception trenches and cut-off wall were proposed as the downgradient groundwater control system;
- Effluent discharge standards for the treated groundwater were proposed;

- The extent of contaminated soil from three isolated areas and the Northeastern Corner were defined. Contaminated soil was only identified at two of the isolated areas (at BP01/BP02 and around GW-38) and was not identified in the Northeastern Corner;
- The limits of landfill waste were defined; and
- The SVE system for the removal of organic vapors within the permeable materials adjacent to portions of the buried waste lagoon was determined not to be feasible.

1.3 Project Objectives and Scope

This RA FSP is an integral part of the RA Quality Assurance Project Plan (QAPjP) and consolidates the sampling requirements for use by the field personnel during the construction of the RA's. This plan includes the sampling plans, sampling procedures and methodologies, and details of the RA sampling efforts to be used during the RA construction activities. The RA FSP also defines the methodologies and procedures to be used to re-evaluate and confirm the baseline surface water and groundwater conditions at the end of the RA construction activities. Sampling and analysis activities to be used after the RA construction activities are defined in the Long Term Performance Plan (LTPP).

The following field sampling activities will be conducted during the RA construction activities:

- Well Abandonment;
- Sample and analyze soils during excavation of contaminated soils;
- Install piezometers and groundwater monitor wells;
- Measure the potentiometric surface in monitor wells, in piezometers, in the interceptor trench, and in the East Fork of Mill Creek;
- Sample and analyze groundwater from monitor wells; and
- Sample and analyze surface water.

Throughout this document Standard Operating Procedures (SOPs) will be referenced. These SOPs (see Appendix I) define sampling methodologies and procedures that will be followed during the RA field activities.

1.4 RA Supporting Work Plans

The following work plans will be followed during the implementation of the RA construction activities.

1.4.1 RA Quality Assurance Project Plan

The RA QAPjP defines the site-specific Quality Assurance (QA) methods and quality controls (QC) that will be used to collect and analyze samples during this project. The RA QAPP is designed to ensure that the quality, precision, accuracy and completeness of the data generated meets the established data quality objectives.

1.4.2 RA Health and Safety Plan

The RA HASP addresses the site-specific health and safety requirements that will be used during the field activities of this project. These health and safety requirements were developed in accordance with the Occupational Safety & Health Administration (OSHA) regulations and U.S. EPA guidance documents.

1.4.3 RA Spill Prevention Control and Countermeasures Plan

The RA Spill Prevention Control and Countermeasure Plan (SPCC) defines the methods and procedures in the event of a spill during the RAs or subsequent monitoring activities. This plan covers spill procedures, notification procedures, and spill prevention methods.

1.4.4 RA Air Monitoring Plan

The RA Air Monitoring Plan (AMP) defines the project requirements and SOPs to be used for both personal air monitoring and perimeter air monitoring. The intent of the air monitoring is to determine the effectiveness of on-site controls (i.e., monitor airborne contaminant migration in excess of the action levels specified in the RA AMP and the RA HASP) and to define the level of personal protective equipment (PPE) to be worn by the RA field personnel.

1.4.5 RA Contingency Plan

The RA Contingency Plan (CP) defines the methods and procedures to be used during the remedial activities at the site. This plan addresses responsibilities of plan implementation, emergency service contacts and protocols for implementation of the plan. Types of emergencies addressed in the plan includes fires and explosions, serious personal injury, chemical exposure, release of hazardous materials and unsafe working conditions.

1.4.6 RA Construction Quality Assurance Plan

The RA Construction Quality Assurance Plan (CQAP) defines the performance requirements to be used to monitor the construction materials and activities during the implementation of the RA's. This plan also specifies the sampling requirements and procedures to be used to evaluate the conformance of the RA construction contractor(s) with project drawings and specifications.

1.4.7 RA Long Term Performance Plan

The RA LTPP defines the sampling requirements to monitor the effectiveness and performance of the RA components. Groundwater and surface water monitoring will be conducted to determine if the water quality Applicable or Relevant and Appropriate Requirements (ARAR's) are exceeded at any time during operation of the RA. In addition, the groundwater depression evaluation with respect to depth of buried waste will be conducted. The LTPP will be implemented after construction of the RA components including the final RA surface water and groundwater sampling event.

2.0 RA FIELD INVESTIGATIONS

This document includes detailed descriptions of field activities to be used during the construction of the RA's at the Skinner Landfill Site. These field activities are as follows:

- Abandon 32 monitor wells;

- Excavate the contaminated soil/waste in two isolated areas (the buried pit area BP01/BP02 and around well GW-38);
- Install 9 monitor wells downgradient of the interception system, 6 piezometers upgradient of the interception system, 6 piezometers within and around the landfill, and 1 DNAPL well downgradient of the buried waste lagoon;
- Measure the groundwater levels in 12 piezometers, 1 DNAPL well, 9 new monitor wells, 5 existing monitor wells, and in the interceptor trench;
- Measure the surface water elevations at two bench mark locations;
- Measure the presence of DNAPL's in one DNAPL well, 9 new monitor wells, 2 existing monitor wells, and in the interceptor trench;
- Sample and analyze groundwater during RA construction activities; and
- Sample and analyze the surface water quality at eight locations during the RA construction activities.
- Determine depth of waste at piezometers P-9 through P-12

2.1 Abandon Existing Monitor Wells

Thirty-two existing groundwater monitor wells (see Table 1) will be abandoned during the construction of the RA's. The existing well locations are shown on Drawing 1. Monitor wells will be abandoned per the requirements of OEPA using the following procedure:

- Remove outer protective casing from the well. Excavate and remove guard posts and the concrete pad;
- Attempt to pull well casing out of the ground. If the well casing cannot be pulled out of the ground over-drill the casing and ream the borehole clean;
- Boreholes will be grouted with neat cement or bentonite grout. The cement grout will consist of Portland cement, bentonite and water in proportions of not more than 8 gallons of potable water per bag of cement (94 lbs) and bentonite powder (5 lbs);
- Grout will be tremied into all boreholes greater than 40 ft in depth. Grout will be poured down the boreholes less than 40 ft in depth; and
- Surface will be filled in to avoid a depression over the well location.
- Repeated attempts have been made to locate Monitoring Wells MW-12, MW-14, MW-21 and MW-25. Earth Tech will continue to attempt to locate these wells, however, this activity is dependent upon their receipt of well data from the EPA.

2.2 Excavation of Contaminated Soil

The extent of contaminated soil at two locations was refined during the Contaminated Soil Design Investigation. The contaminated areas include the Buried Pit area (BP01/BP02) and the area around monitor well GW-38. The extent of the contaminated soil and proposed soil sample locations are included in Figures 2 and 3.

The contaminated soil will be excavated and moved to the landfill for incorporation under the landfill cover. After excavation of the contaminated areas, soil samples will be collected from each excavation (from the 4 sidewalls and from the bottom of the excavation). A pre-cleaned stainless steel spoon will be used to collect the samples and the samples will be placed in laboratory-supplied sample jars. The laboratory will supply certified pre-cleaned sample containers. Custody requirements of the samples are defined in Section 5.0 of the RA QAPP.

Soil samples will be analyzed for the parameters listed in Table 7. Based on a comparison of the results of this analysis with the trigger levels listed in Table 7, it will be determined if the contaminated soil has been removed. If the analysis is less than the trigger levels, the excavations will be backfilled with clean sand and gravel. However, if the chemical analysis of any of the soil samples indicates constituents are greater than the Table 7 trigger levels additional soil will be excavated. In the event the trigger levels are exceeded, excavation will continue until the chemical analysis of the samples taken are less than the trigger levels in both areas.

During the remedial action if drums are discovered, the excavation will cease and the field team leader will be notified. The field team leader with the help of a chemist will determine if the drum can be relocated to an area maked off for the staging of drums for offsite treatment/disposal. Like samples will be composited and shipped to the laboratory for analysis.

3.0 GROUNDWATER MONITORING

Per Section II, d. of the SOW, a downgradient groundwater control system is required at the Skinner Landfill Site. This interception system is designed to intercept and capture groundwater migrating from the landfill to the East Fork of Mill Creek. The general requirements and site location of the Interception System are defined in Section 2.0 of the Design Report.

The groundwater monitoring system will be used to assess the long-term performance of the Groundwater Interception System (interceptor trench and cut-off wall), evaluate the possible presence and/or movement of DNAPLs in the vicinity of the buried waste lagoon and evaluate the groundwater depression underneath the cover after completion of the RA construction activities (see LTPP).

3.1 Proposed Monitor Well and Piezometer Locations

Nine new groundwater monitor wells (see Table 2 for well numbers) and two of the remaining five groundwater monitor wells (GW-06 and GW-07R) are proposed as sampling locations. These wells will be used to confirm or update the groundwater conditions and to monitor the long term performance of the groundwater interception system. One additional monitor well (GW-66) will be installed downgradient of the buried waste lagoon to monitor for the presence of DNAPLs in accordance with the Statement of Work.

Twelve new piezometers will be installed to monitor liquid levels. Six piezometers (P-1 to P-6) will be located upgradient of the interception system to re-evaluate and confirm the water level elevations upgradient of the groundwater interception system and to determine the water level elevations after construction of the RA's. The other six piezometers (P-7 to P-12) will be installed in and around the landfill to monitor water levels within the landfilled waste after the RA cover construction activities.

Factors considered for selecting the monitoring well and the piezometer locations included:

- The existing hydrogeology relative to the location of the Skinner Landfill, the proposed trench alignment, and the East Fork of Mill Creek;

- The presence of vertically and laterally transitional soil units that are discontinuous, and vary in permeability and thickness;
- Site morphology; and
- Potential affects on groundwater flow by the construction of the interception system and its proximity to the East Fork of Mill Creek.

The number and spacing of monitor wells were chosen based on data and conclusions reported for the GWDI. The final location of the individual wells may be refined in the field based on data collected during the well installation.

The proposed groundwater monitor well locations to be sampled for chemical analysis include the two existing monitor wells (GW-06 and GW07R) and the nine new monitor wells (GW-58 to GW-65). In the event GW-06 is damaged during the excavation of the soil around GW-38 and cannot be repaired, a replacement well (GW-06R) will be installed to replace GW-06. The monitor well and piezometer locations are shown in Drawing 2. The target depth of the monitor wells is shown in Table 4. The final depth of the screened interval may be refined based on data collected during the well drilling.

3.2 Borehole Drilling and Sampling

Four and one-quarter-inch I.D. hollow stem augers will be used to drill through the unconsolidated sediment overlying the bedrock. Subsurface samples of the undisturbed soil will be collected from each borehole for observation and field description. The samples will be collected by using a continuous sampler, in advance of the auger bit. Samples will be scanned in the field using a PID.

Boreholes that will be drilled into the bedrock will be drilled to a depth of approximately two feet below the sediment-bedrock interface (except the piezometers in and around the landfill cover which will be completed at least 10 feet below the potentiometric surface). Bedrock drilling will be conducted using an HQ (4-inch) size diamond-bit, core barrel. Tap water will be added to the borehole to lubricate and cool the drill bit while coring. The estimated volume of water introduced to the borehole during coring will be recorded by the driller. Similarly, the estimated volume of water recovered from the borehole will be recorded by the driller. For subsequent well development three times the difference in these two estimates (water introduced -water recovered) will be added to the minimum volume of water to be removed. All water recovered will be collected and transported to the top of the landfill for disposal at the decontamination pad.

The sediment and bedrock samples collected during borehole drilling will be stored on-site. The samples will be stored in labeled jars and core boxes, and kept under a tarp within the security fence. Samples will be retained for at least one year.

A boring log (see Figure 6) describing the rock and soil samples will be completed in the field by a Geologist. An example Soil descriptions will include particle size, moisture content, color (using a standardized color chart), consistency and plasticity, fracturing, reactivity to hydrochloric acid (HCl), soil classification and percent recovery. Rock descriptions will include general rock type, color, characteristics affecting groundwater movement and signs of weathering. Characteristics affecting groundwater movement include estimated porosity, estimated permeability, fracturing and bedding. Signs of weathering will include dissolution features, fracture filling, and iron staining. Drill cuttings generated during installation of the monitor wells and piezometers will be containerized and transported to the top of the landfill. The cuttings will be incorporated under the landfill cover during the RA cover construction.

3.3 Well and Piezometer Construction

Monitoring wells consist of two-inch diameter PVC pipe. Piezometers will be constructed of 1-1/4-inch diameter PVC Pipe. After drilling to the target depth (see Table 4) the PVC monitor wells or the PVC piezometers will be installed in the boreholes. Well casing and screen will be Schedule-40 PVC with water tight, locking threads. The screen will be machine cut and will have 0.010 inch slots. Monitor wells GW-58 to GW-65, DNAPL well GW-66, and piezometers P-1 to P-6 will be completed with 10-ft screens. Piezometers P-7 to P-12 will be completed with 15-ft screens. Each screen will be capped at the bottom using a threaded, locking bottom cover. The PVC screen will be placed across the target zone, identified in Table 4. All well screens will be positioned such that 2 to 3 feet of the slotted portion is above the water table.

After the casing and screen is set in the borehole, a No. 5 quartz sand (or equivalent) will be slowly poured into place and the augers will be pulled back, keeping sand in the augers at all times. When the level of the sand pack is 2 foot above the top of the screen, one foot of No. 7 quartz sand (or equivalent) will be placed on top of the No. 5 sand as a filter pack. A minimum of a 2-ft thick layer of bentonite chips or pellets will be placed above the No. 7 sand and allowed to hydrate per the manufacturers specifications. The remainder of the borehole well annulus will be filled with cement-bentonite grout using a tremie pipe. Figure 7 illustrates an example of a well and piezometer construction diagram.

The monitor wells and all piezometers will be finished at the surface with a locking guard casing (with weep hole), anchored in a 2-ft by 2-ft by 0.5-ft concrete pad. The well ID number will be marked on the guard casing for ease of identification. After completion of the monitor wells and piezometers each location will be surveyed for elevation control. The survey involves determining the elevation of the ground surface and top of the inner riser at each location. Each measurement will be surveyed to the nearest one-hundredth of a foot vertically and tenth of a foot horizontally.

Piezometers P-7 to P-12 will be located in and around the landfill cover. The piezometers will be installed prior to the installation of the landfill cover and will not be constructed with the locking guard casing or concrete pad until after the construction of the landfill cover. During the construction of the landfill cover additional sections of PVC risers may need to be added to the piezometers as the elevation of the landfill is raised with the addition of the landfill cover material. During the cover construction, a high density polyethylene (HDPE) "boot" will be installed over the piezometers and welded to the HDPE landfill liner. Upon completion of the landfill cover, the locking guard casing and concrete pad will be installed at each of the landfill piezometers.

The groundwater wells GW-58 to GW-65, DNAPL well GW-66, and piezometers P-1 to P-6 will be installed after the groundwater interception system has been installed.

3.4 Monitor Well and Piezometer Development

The completed monitor wells and piezometers will be developed utilizing the following three step process:

- Surge using a decontaminated surge block to loosen sediment or sand that may be lodged in the well screen or fine grain sediment "caked" on the borehole annulus. The surge block will be vigorously moved up and down in the casing, across the entire length of the screen.
- Use a decontaminated bailer to remove any accumulated sediment in the bottom of the screen.

- Pump groundwater using a submersible pump.

Development (pumping) will continue until at least: a) three times the well volume and the net volume of water introduced during coring have been removed and b) the pH, temperature, turbidity, and specific conductance of the development water has stabilized.

The development water will be considered stabilized when field readings of three consecutive well and piezometer volumes of groundwater agree as follows: pH is ± 0.1 su, temperature is $\pm 1^{\circ}\text{C}$, turbidity is less than 10 NTU, and conductivity is ± 10 umhos. All development water generated will be collected and transported to the decontamination pad for disposal.

4.0 GROUNDWATER SAMPLING PLAN

Groundwater samples will be collected once after completion of the RA construction activities as part of the RA. Groundwater sampling and analysis will be conducted at the locations identified above.

4.1 Sampling Procedure Summary

Groundwater sampling will include the following procedures:

- Pre-sampling Observations and Measurements (Section 4.2);
- Sample Collection (Section 4.3);
- Sample Preparation and Preservation (Section 6.4.3); and
- Chain-of-Custody control (Section 6.4.4).

Specific procedures, described in the sections that follow, include measurement of water levels, measurement of DNAPLs, purging of wells, field measurements of pH, specific conductance, and temperature, sample collection (bottles, preservation and shipping), chain-of-custody control, and field QA/QC procedures. Operation and maintenance procedures for instruments used for field measurements are presented in Appendix I.

4.2 Pre-Sampling Observations and Measurements

Observations and measurements will be documented in the field logbook prior to sample collection at each monitoring well.

4.2.1 Well Integrity

The purpose of monitoring well integrity is to ensure that the physical integrity of all monitoring wells is maintained and that groundwater samples are representative of the groundwater quality of the monitored zone. The sampling team is responsible for assessing the following conditions surrounding the well and noting any potential problems in the field logbook:

- Condition of the surface seal;
- Erosion or ponding of surface water/runoff around the casing;
- Subsidence of the soil materials surrounding the casing;
- Animal or insect activity in or around the casing;
- Obstructions which preclude access to the well;
- Determine if flooding of the well has occurred; and
- Other conditions which affect access or obtaining samples or sample integrity.

The conditions near the casing are important to maintaining the integrity of the well. For example, the surface seal acts to prevent surface water from traveling along the casing to the groundwater. Any damage to the seal, including cracks, must be noted and subsequently corrected. Cracks in the surface seal may allow surface water near the well to seep around the plug and down the casing. Such seepage may allow undesirable mixing of surface water with the groundwater which is to be sampled.

The following observations of the external protective casing are to be noted and recorded by the sampling team in the field logbook:

- Locked external guard casing;
- Animal or insect activity in or on the external guard casing;
- Water in the annular space;
- Severe bends or cracks in the external guard casing;
- Cracks in the concrete pad;
- Blocked weep hole; and
- Other conditions affecting the external guard casing including damage caused by vandalism.

The external guard casing serves to protect the internal well casing. Water in the guard casing is undesirable because it may freeze and crush the PVC well casing. Weep holes in the guard casing must be kept clear to allow water to drain from the guard casing.

The sampling team will visually inspect the PVC well casing before each sampling event. The condition of each well will be noted in the field note book as follows:

- Loose casing;
- Bent or damaged casing;
- Any obstructions in the casing; and
- Condition of the well cover.

The field sampling team will report well integrity discrepancies to the Project Manager. The sampling team must immediately notify the Project Manager by telephone if it is impossible to sample a well, or if the sampling team thinks the sample integrity is compromised.

4.2.2 Measurement of Groundwater Elevations

Water-level and depth to well-bottom measurements will be recorded at each of the selected monitoring wells and piezometers (GW-58 to GW-66, GW-06, GW-07R, GW-24, GW-26, GW-30, and P-1 to P-12) using a portable electronic measuring tape. Water levels will also be collected from the interception system and two surface water bench mark locations (BMSW-1 at the bridge near SW-51 and BMSW-2 at the railroad bridge near SW-53). Measurements will be recorded to an accuracy of ± 0.01 feet and will be documented in the field logbook. The measurements will be made relative to a surveyed notch in the top of the PVC casing. The data will be used to calculate the volume of water in the respective well casings and to prepare a potentiometric surface map of the area along the interception system alignment. Additionally, the presence or absence of DNAPLs will be measured using a pre-cleaned electronic solvent-water probe in each of the selected wells and piezometers. Measurements will be recorded to an accuracy of ± 0.01 feet and will be documented in the field logbook. The measurements will be made relative to a surveyed notch in the top of the well casing. The water-level and solvent-water probes will be decontaminated between measurements in accordance with the procedures described below. The groundwater and surface water monitor locations are shown in Drawings 2 and 3 respectively.

4.3 Groundwater Sampling

Purging and sampling equipment will be dedicated to each well to prevent potential cross contamination. Groundwater samples from monitor wells will be extracted using dedicated submersible electric pumps, positive air displacement pumps, or stainless steel and/or Teflon™ bailers as listed below:

- Teflon Bailers
Aqua Bailers TF 16 x 26 SCW 36"
- Stainless Steel Bailer
Mono-Flex L010101
- Electric Submersible Pump
Grundfos Redi-Flo I
- Positive Air Displacement Pump
Clean Environmental Equipment AP-2/TL

The same type of pump or bailer will be used at each well or piezometer.

4.3.1 Well Purging

A least three water column volumes, measured from the top of water to the base of the well, will be purged from each monitoring well prior to sampling. Purging the wells assures that samples are drawn from the aquifer and not from stagnant water left in the well between sampling events. Stabilization of pH, specific conductance, and temperature during well purging must occur before sampling. Purging will be considered complete when the measurements of samples of three consecutive water column volumes agree as follows: pH is ± 0.1 su, temperature is $\pm 1^{\circ}\text{C}$, and conductivity is ± 10 umhos). Purge volume calculations will be as follows: Depth to water will be subtracted from the total well depth, and the result multiplied by a conversion factor for well casing size (0.17 for 2.0-inch I.D. wells). This value will be one water column volume, in gallons, which will be multiplied by three to calculate the minimum required purge volume. A graduated five-gallon bucket will be used to measure the volume purged. Actual purge volumes and start and stop times will be recorded in the field logbook. Purge water will be collected and transported to the Decontamination Area where it will be poured onto the top of the landfill.

When a well bales dry during the well purging process, the well will be allowed to recharge. The samples will be collected as soon as sufficient volume has accumulated in the well.

4.3.2 Sample Collection

Groundwater samples from monitor wells will be extracted using dedicated submersible electric pumps, positive air displacement pumps, or stainless steel and/or Teflon™ bailers. Sample containers will be filled directly from the bailer (or pump) with minimal air contact and without allowing the sampling equipment to contact the containers.

When testing for the presence or absence of Dense Non-aqueous Phase Liquids (DNAPLs) is to be performed, this testing will be performed prior to sample collection. The presence of DNAPLs will be measured with the interface probe used to measure the wells' water levels. After the presence/absence of the DNAPLs have been determined, the groundwater samples will be collected from the wells.

Groundwater samples will be collected unfiltered (except for metals which will be collected as filtered and unfiltered) and analyzed for the parameters listed in Tables 8, 9, and 11 (Table 1 from the ROD, as modified by the GWDI). An in-line disposable 0.45 μ filter will be used to collect the groundwater samples for metals analysis. Groundwater samples for Volatile Organic Compounds (VOC) analysis will be collected first. Care will be taken to slowly fill the sample containers to minimize volatilization of the VOCs. Each VOC sample container will be filled with no head-space in the sample container. After collecting the VOC samples, the sample containers for SVOCs, Metals, and Cyanide will be filled, respectively.

Measurements of pH, temperature, and specific conductance will be recorded in the field logbook immediately upon sample collection. The analytical procedures for these field measurements are specified in the field measurement SOPs contained in Appendix I of this document. Field measurements will be made in accordance with proper operating procedures for the equipment.

5.0 SURFACE WATER MONITORING PLAN

During the RA, construction activities associated with the installation of the groundwater interception system and the landfill cover could have an impact on the surface water quality of the East Fork of Mill Creek and the Skinner Creek. To evaluate the potential impact(s), the surface water monitoring program will include both chemical and biological monitoring. Surface water monitoring shall commence immediately prior to initiation of RA construction. Surface water sampling will be conducted according to the procedures defined in this section.

5.1 Surface Water Monitoring Point Locations

During the RA, contaminated soil excavation activities at BP01/BP02 and around GW-38 and cover and interception system construction activities may have an impact on the surface water quality of the East Fork of Mill Creek and the Skinner Creek. To monitor the potential impacts, the East Fork of Mill Creek and the Skinner Creek will be evaluated during the RA by collecting and analyzing surface water samples from five sample locations (see Drawing 3 for location of SW-50, SW-51, SW-52, SW-53 and SW-54). Surface water samples from SW-50, SW-51, SW-52, and SW-53 will be collected monthly until the completion of the RA construction activities. Surface water samples from SW-54 will be collected monthly until the completion of the RA excavation activities at BP01/BP02.

Surface water run-off associated with the installation of the groundwater interception system and the landfill cover may have an impact on the surface water quality of the East Fork of Mill Creek. To monitor the potential impacts, the East Fork of Mill Creek will be evaluated during the RA by collecting and analyzing surface water samples from three run-off sample locations (see Drawing 3 for locations of SWD-1, SWD-2 and SWD-3) and comparing the RA results to the data collected during the baseline surface water study conducted during the GWDI. Run-off samples will be collected monthly until the completion of the RA construction activities (but only after a rain event that qualifies for NPDES sampling).

After completion of the RA construction activities, the baseline surface water conditions defined during the GWDI will be re-evaluated to determine if the conditions have changed. To monitor the baseline water quality, surface water samples will be collected and analyzed from four sample locations (see Drawing 3 for locations of SW-50, SW-51, SW-52 and SW-53). These surface water samples will be collected within two week of completion of the RA construction activities and the results will be compared to the data collected during the GWDI.

5.2 Sampling Procedure Summary

Surface water sampling will include the following procedures:

- Pre-sampling Observations and Measurements (Section 5.2);
- Sample Collection (Section 5.2.1);
- Sample Preparation and Preservation (Section 6.4.3); and
- Chain-of-Custody control (Section 6.4.4).

5.2.1 Pre-Sampling Observations and Measurements

Observations and measurements will be documented in the field logbook prior to sample collection at each sample point. These observations will include an estimate of stream surface-flow velocity, measurements of pH, specific conductance, dissolved oxygen, and temperature. Visual observations will include any potential impact, such as silting, to Skinner Creek or East Fork of Mill Creek.

Run-off samples will be collected at locations SWD-1, SWD-2 and SWD-3 within 24-hours after a rainfall of 0.10 inch or greater. The time and amount of the most recent rainfall will be verified by measurements recorded in the on-site weather station (See Air Monitoring Plan). The National Weather Service at Greater Cincinnati Northern Kentucky Airport will be contacted for rainfall data in the event that the on-site weather station is not operational.

5.2.2 Sample Collection

Sampling will begin at the sample location most downstream and proceed progressively to the upstream locations. Samples will be collected as near to midstream (or midchannel) as possible. Sampling at midstream may be changed in the field due to practical considerations such as safety and minimizing disturbance of sediment by the sample team walking in the stream. The samples will be collected directly from the stream by immersing the sample bottle with its opening pointed down stream. Collecting substrate and floating debris will be avoided. Sample bottles containing preservative should not be immersed in the stream. Instead, they should be filled with an intermediate laboratory supplied bottle. Samples for field parameters will be collected in a clean sample bottle. Field parameters will not be measured directly in the stream unless a stilling well is installed. Stream flow may affect measurements reported by the instruments.

All surface water samples will be analyzed for the parameters listed in Tables 8, 9, and 11 until the parameter list is modified by the U.S. EPA. Samples for VOC analysis will be collected first. Care will be taken to slowly fill the sample containers to prevent volatilization of the VOCs. Each VOC sample container will be filled with no head-space in the sample container. After collecting the VOC samples, the sample containers for SVOCs, Metals, and Cyanide will be filled, respectively.

Measurements of pH, temperature, specific conductance, and dissolved oxygen will be recorded in the field logbook immediately upon sample collection. The analytical procedures for these field measurements are specified in the field measurement SOPs contained in Appendix I of this document. Field measurements will be made in accordance with proper operating procedures for the equipment.

5.3 Biological Sampling

Included in the RD are plans for Biological Sampling and analysis within the East Fork of Mill Creek. This sampling includes both fish and macroinvertebrates. After further review of the stream, the methods outlined

in the RD are inappropriate based on the apparent low flow and the intermittent nature of the creek. The RD calls for electro shocking of fish and Hester-Dendy multiple plate samples for macroinvertebrates. As an alternate to this method, sampling will be conducted in accordance with the Ohio EPA, Division of Surface Water procedures outlined in the following document: Primary Headwater Habitat Assessment Program , Field Evaluation Manual, June, 1999. A copy of this document is provided in Appendix II.

6.0 GENERAL SAMPLING PROCEDURES

The following sections address procedures that are applicable to both surface and groundwater sampling.

6.1 Sample Identification Nomenclature

A sample nomenclature system will be used to permit easy identification of the sample types and sample locations when retrieving data, reviewing analytical results, or performing data manipulations. The system selected for this project will consist of the following:

- The two-letter site code will be "SK";
- The matrix code will be either SS for soil samples, GW for groundwater samples, CSW for remedial action construction surface water samples, SW for surface water samples, or SWR for surface water run-off samples, MI for macroinvertebrate samples, FS for fish community samples, FSB for fish bioassay samples;
- The designation code (F) for filtered and (U) for unfiltered will be used to distinguish filtered and unfiltered samples;
- The location number will be a two digit number unique to the sample location;
- The QA sample description will be either FB for field blank, FD for field duplicate, TB for trip blank, MS for Matrix Spike or MSD for Matrix Spike Duplicate;
- The sampling round will be designated with a three digit number starting with "100" to avoid potential confusion with prior sampling.

For example, a sample with the sample number SK-SWD3-100 refers to the Skinner Landfill surface water run-off sample, from location SWD-3, collected during the first RA construction sampling event.

6.2 Disposal of Cuttings and Liquids Generated During the Field Activities

Final disposition of all drill cuttings and excavated soil will be on top of the Skinner Landfill beneath the landfill cover. To prevent any soils from eroding off the landfill and migrating off-site, auger cuttings will be drummed at the drill site and the drums transported on top of the landfill. The soil will remain in drums until the earthwork contractor is ready to prepare the cover subgrade. Excavated soil in drums will be covered with a tarp.

All liquids generated during the field activities will be containerized. These containers will then be transported to the decontamination pad where they will be poured on to the decontamination pad for disposal on top of the landfill. If any decontamination fluids or other Investigation Derived Waste (IDW) is generated after the emplacement of the landfill cap, these materials will be containerized for off-site disposal or, if permission is granted, discharged to the POTW.

6.3 Decontamination Procedures

The following six-step process will be used for decontaminating sample devices in direct contact with the sample:

- 1) Wash sampling equipment in a solution of potable water and non-phosphate detergent;
- 2) Rinse with reagent grade Hexane (if DNAPLs have been determined to be present by visual observation, by the DNAPL probe or through chemical analysis);
- 3) Rinse with reagent grade Methanol (if DNAPLs have been determined to be present by visual observation, by the DNAPL probe or through chemical analysis);
- 4) Rinse with clean potable water;
- 5) Rinse with organic-free deionized water; and
- 6) Air dry equipment and wrap in aluminum foil if sampling equipment is to be stored or transported.

For drilling and heavy excavation equipment, the following decontamination process will be used:

- Remove all large particles of soil with a shovel or other scraping device;
- Clean the surface of the equipment with a high pressure hot water cleaner using clean potable water;
- Let the equipment air dry; and
- Store the equipment in a clean area until it is used.

6.4 Sample Handling and Analysis

All samples collected for chemical analyses during this project are assumed to be classified as low level hazard samples or environmental samples. Procedures for low level samples are described below. Samples will be withdrawn from the monitor wells with the same equipment used for purging. Sample containers will be filled directly from the bailer (or pump) with minimal air contact and without allowing the sampling equipment to contact the containers.

Groundwater and surface water samples for VOC analysis will be collected first. Care will be taken to slowly fill the sample containers to minimize potential volatilization of the VOCs. Each VOC sample container will be filled with no head-space. After collecting the VOC samples, the sample containers for SVOCs, metals, and cyanide will be filled, respectively.

6.4.1 Field Analysis

Before use in the field, instruments will be calibrated using procedures furnished by the instrument's manufacturer. Sampling personnel will ensure that the instruments are in proper working order and capable of providing accurate and reliable data prior to the sampling event. Equipment logbooks will be maintained and will include the repair history of each instrument. Calibration checks will be recorded in the field logbook per the procedures defined in the SOPs contained in Appendix I.

Measurements of pH, temperature, specific conductance, and dissolved oxygen will be recorded in the field logbook immediately upon sample collection. The procedures for these field measurements are specified in the SOPs contained in Appendix I.

6.4.2 Sample Preparation

As each sample is collected in the field, it will be placed in a labeled sample bottle (see Figure 4 for an example of the sample label) with the appropriate chemical preservatives and stored in an iced cooler. Chain-of-custody (see Figure 5) documents will be prepared for all samples which will be shipped to the laboratory (per the RA QAPP requirements). Since multiple analyses will be required, different types of containers and preservatives will be necessary. Sample containers and preservatives will be supplied by the laboratory. Containers for collecting samples for VOC analysis will be filled to slightly more than full

before the cover is placed on the container to ensure that there is no head space or loss of VOCs from the sample. The number and frequency of the trip blanks, rinsate samples, duplicate samples, and matrix spike/matrix spike duplicates are specified in Table 3 of this document. Samples will be shipped to the laboratory per Section 5.0 of the RA QAPP.

6.4.3 Sample Bottle Preparation and Sample Preservation

Appropriate sample containers and preservatives are presented in Table 5 for groundwater and surface water samples, and Table 6 for soil samples. Samples requiring preservatives shall be preserved in the field with the appropriate reagents supplied by the laboratory. All sample bottles will be certified precleaned. All sample bottles provided by the laboratory will be in accordance with current U.S. EPA guidelines (i.e., Specifications and Guidance for Obtaining Contaminant Free Sample Containers, April 1992).

6.4.4 Storage and Shipping

Samples which will be shipped to the laboratory for analysis will be prepared for shipment using the following procedures:

- Tighten each sample bottle lid hand tight. Place custody tape over the lid and the sample label;
- Place packing material (approx. 3-inches) in the bottom of a waterproof cooler;
- Seal bottles in clear plastic bags and place them in a cooler in such a way that they do not touch;
- Place pre-cooled blue ice in plastic bags (minimum of 3) and arrange them in the cooler around the bottles;
- Fill the cooler with the sample bottles and packing material;
- Place the completed paperwork (i.e., chain-of-custody forms) in plastic bags and tape them to the inside of the cooler lid;
- Tape the cooler drain shut (if the cooler has a drain);
- Close the cooler and secure the lid by taping the cooler completely around the outside with strapping tape at two locations;
- Place the laboratory address on top of the cooler;
- Place "THIS SIDE UP" labels on all four sides and "FRAGILE" labels on at least two sides of the cooler;
- Affix custody seals on front right and back left corners of the coolers. Cover seal with wide clear tape and strapping tape as appropriate;
- Ship each sample cooler to the laboratory by Federal Express using "PRIORITY OVERNIGHT DELIVERY";
- Samples will be shipped in accordance with U.S. DOT and IATA/ICAO regulations; and
- Contact the laboratory if shipment is on Friday or the day before a holiday to ensure laboratory personnel are available to receive the shipment on the following day.

All samples will be preserved on the day they are collected and will be shipped within 24 hours of their collection. All samples will be under chain-of-custody procedures from the moment the samples are collected until the samples have been analyzed, the data reported to the U.S. EPA and the samples properly disposed of.

6.4.5 Corrective Actions

Corrective actions must be taken any time a situation develops that threatens data quality. Corrective action may be required if field audits reveal unacceptable deviation from approved procedures. Corrective action

may include immediate resampling and/or reanalysis of a few samples, or the cessation of all analyses with the subsequent resampling and/or reanalysis of all samples upon resolution of the problem.

Specific corrective action for field measurements may include the following:

- Repeat the measurement to check the error;
- Check for all proper adjustments for ambient conditions such as temperature;
- Check the batteries;
- Check the calibration and adjust as necessary;
- Replace the instrument or measurement devices; and
- Stop work (if necessary).

Corrective actions during the field activities may involve:

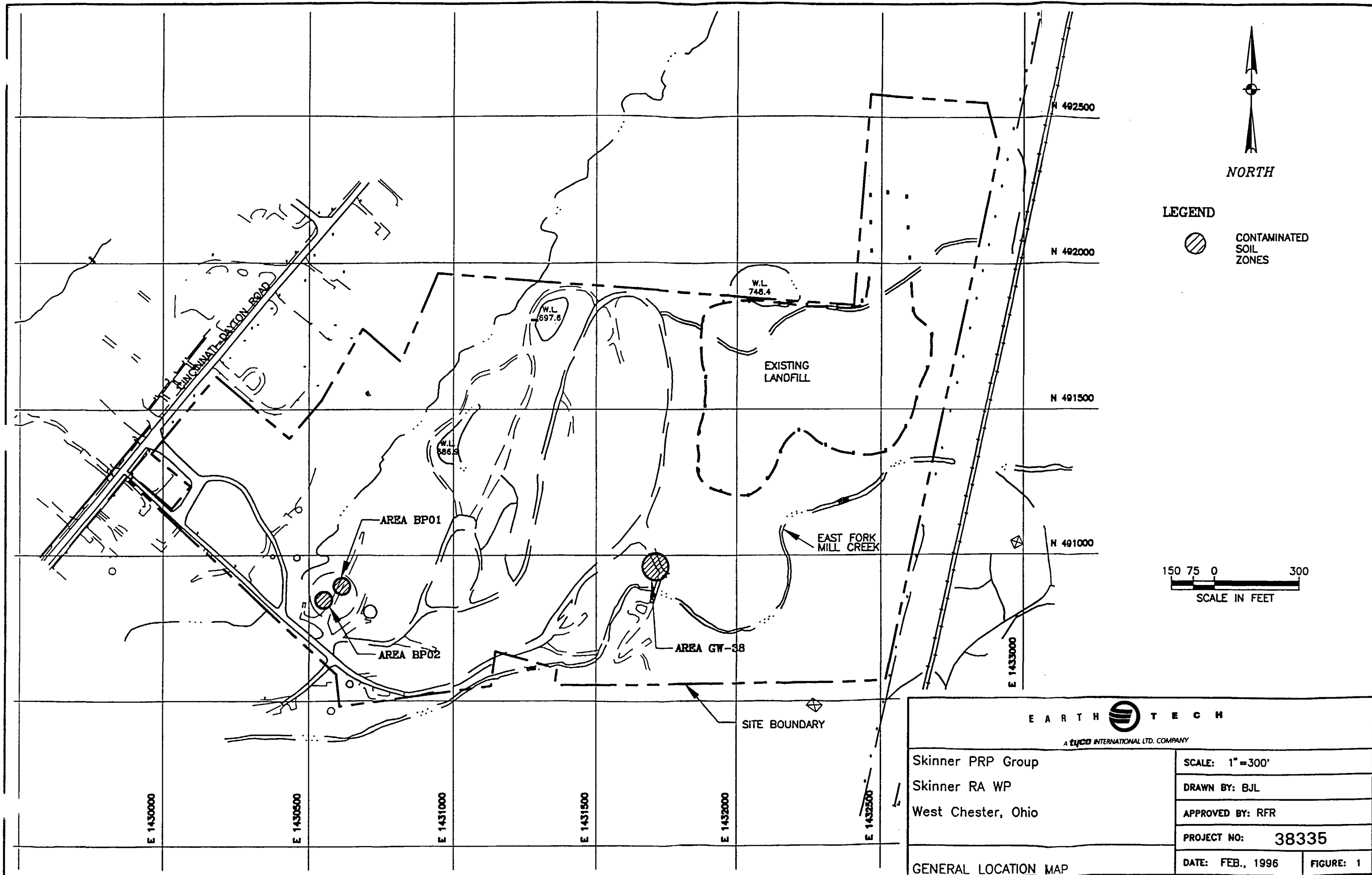
- Field Team Leader;
- Field Team Members;
- Project Manager;
- PRPs Project Coordinator;
- U.S. EPA Personnel; and/or

A QC problem that cannot be solved by immediate corrective action must be thoroughly investigated to determine the extent of the problem and to ensure that all samples affected by the problem are identified and analyzed. If a problem during field activities cannot be immediately solved, the Field Team Leader should contact the Project Manager.

7.0 REPORTING

Data Reports will be prepared during the RA activities. These reports will contain the results of data collected during the field activities; potentiometric surface maps; and a comparison of the analytical results to the baseline conditions. These reports will be submitted to the U.S. EPA for their review and comment.

FIGURES

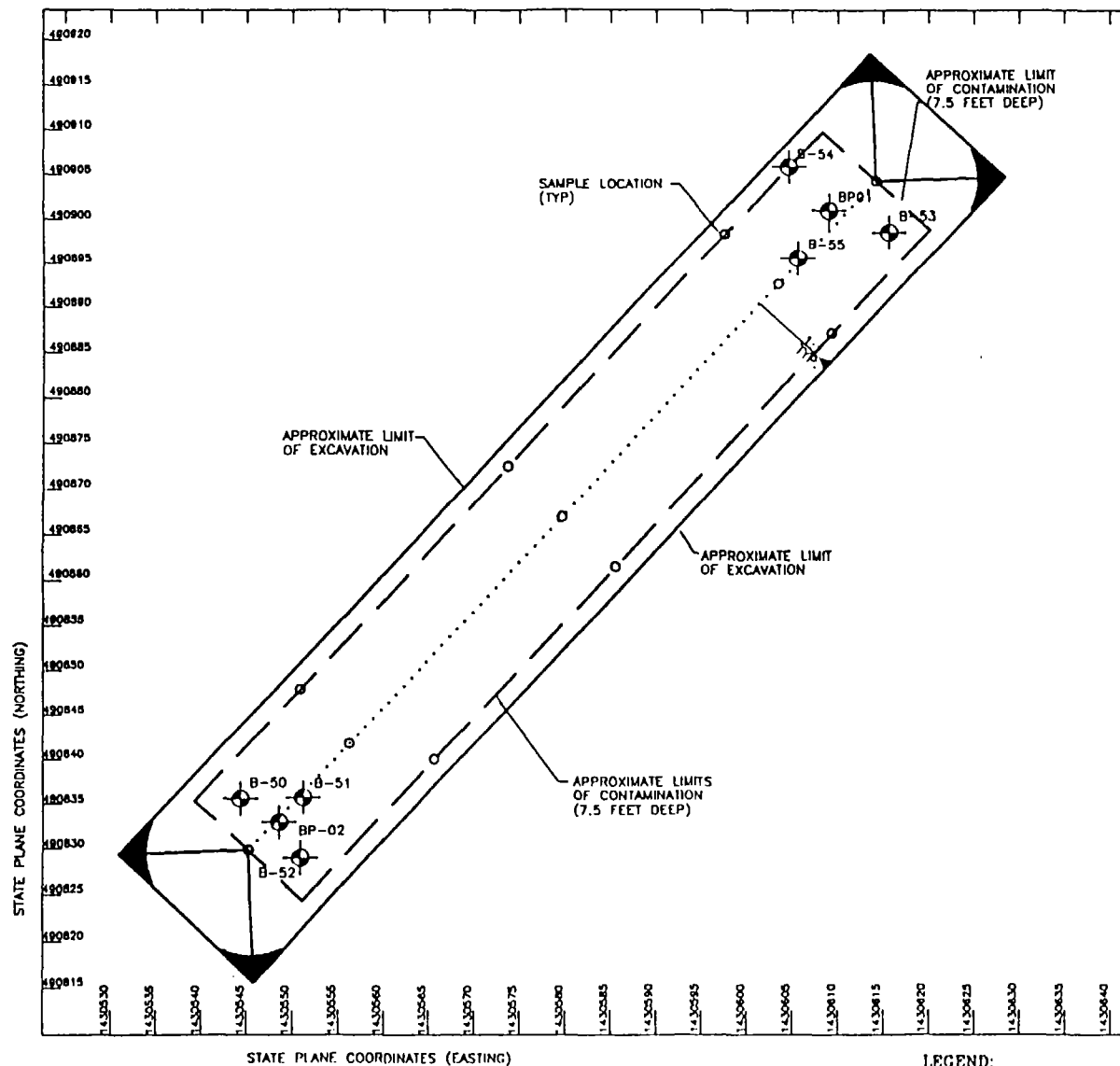
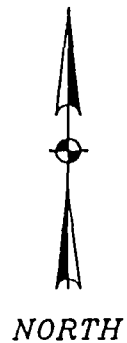


NOTE: THIS CADD DRAWING IS SET UP IN AUTOCAD'S PAPERSPACE ALTERATIONS
MAY BE NECESSARY FOR FILE TRANSLATION TO OTHER CADD PROGRAMS.

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PLOT DATE: 02/22/96



Skinner PRP Group

Skinner RA WP

West Chester, Ohio

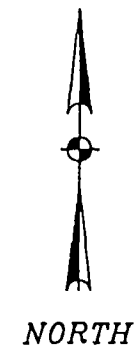
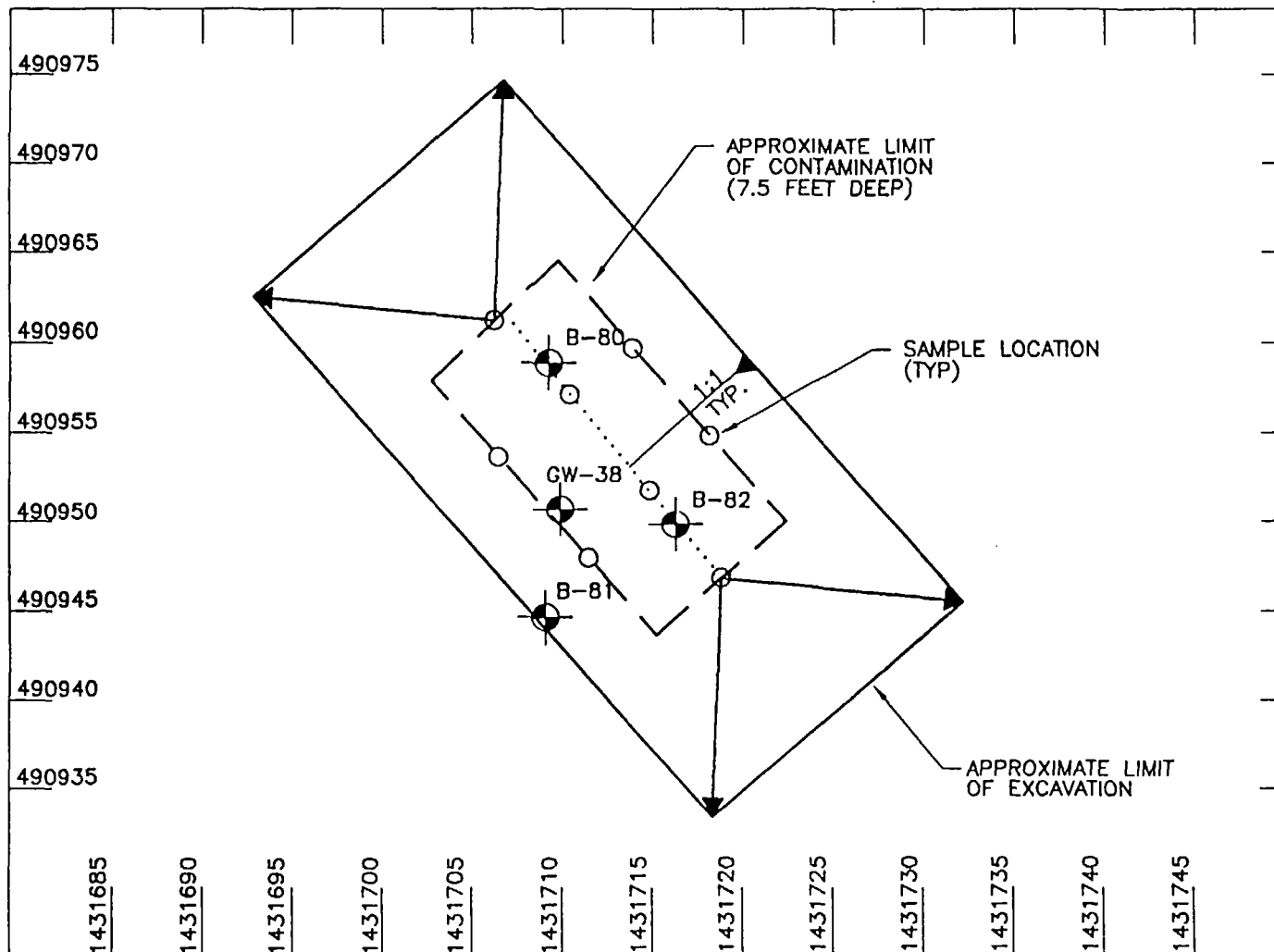
CONTAMINATED SOIL LIMITS- AREA BP01/BP02

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

PROJECT NO. 38335 FIGURE 2

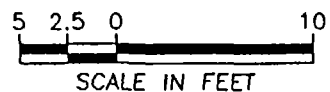
STATE PLANE COORDINATES (NORTHING)



STATE PLANE COORDINATES (EASTING)

LEGEND:

- SAMPLE LOCATIONS
- 10 FOOT EXCAVATION LINE



Skinner PRP Group
 Skinner RA WP
 West Chester, Ohio
 CONTAMINATED SOIL LIMITS-AREA GW-38

EARTH  TECH
 A tyco INTERNATIONAL LTD. COMPANY
 PROJECT NO. 38335 FIGURE 3



Preservative: None
Parameter:

Sample ID: _____

Date: _____ Time: _____

Comp.: _____ Grab: _____

Sampled by: _____

GCAL-01

Figure 4: Sample Label



End... of... of... of... of...

Due Date

Lab use only:

Client: _____
Address: _____

Contact: _____
Phone: _____
Fax: _____

Custody Seal

used ☐ yes ☐ no

in tact ☐ yes ☐ no

Temperature °C _____

Project Name/Number

Sampled By[illegible]

Remarks:

Lab ID

Turn Around Time: ☐ 24-48 hrs.* ☐ 3 days* ☐ 1 week* ☐ Standard ☐ Other

Note: * Non-standard turnaround time request must be pre-scheduled with Laboratory.

Time:

Time:

By submitting these samples, you agree to the terms and conditions contained in our most recent schedule of services.

Figure 5: Chain-of-Custody Form

Matrix¹: W = water, S = soil, SD = solid, L = liquid, SL = sludge, O = oil, CT = charcoal tube, A = air bag

We cannot accept verbal changes. Please fax written changes to (225) 767-5717.

WHITE: CLIENT FINAL REPORT — CANARY: LABORATORY — PINK: CLIENT

GCAL-06 11'98

Sample Boring Log SB-1

FIGURE 6

Skinner Landfill Work Group
ET Project # 38335.03

(Page 1 of 1)

Date Started : 12/21/99
Date Completed : 12/21/99
Project Name : Skinner Landfill Site
Project Location : Butler County,
West Chester, Ohio

Drilling Method : Hollow Stem Auger
Contractor :
Logged By : Pat Higgins



Depth feet Feet	USCS (visual)	GRAPHIC	Water Levels	DESCRIPTION	REMARKS	Interval (feet)	Recovery (feet)	PID (ppm)	Blow Count Graph 10 50
0				CLAY, little silt, trace of fine sand, some organic material present, moist, brown,					
1						0-2	13 3/4'	N/A	
2	CL								
3						2-4		0.0	
4				SILTY CLAY, plastic, soft, moist, brown	samples were taken with a pump and disposable tubing.				
5	CLML					4-6	4 1/4'	0.0	
6				CLAYEY GRAVEL, little coarse sand, poorly graded, non-cohesive, angular, dry, brown					
7					Boring plugged with granular Bentonite.	6-8		1.1*	
8	GC								
9						8-10	30 3/4'	181*	
10				GRAVEL, Poorly Graded, with loose sand, brown					
11	GP					10-12		208	
12									

* samples sent for laboratory analysis of TPH-DRO

Sample Well/Piezometer Construction Diagram

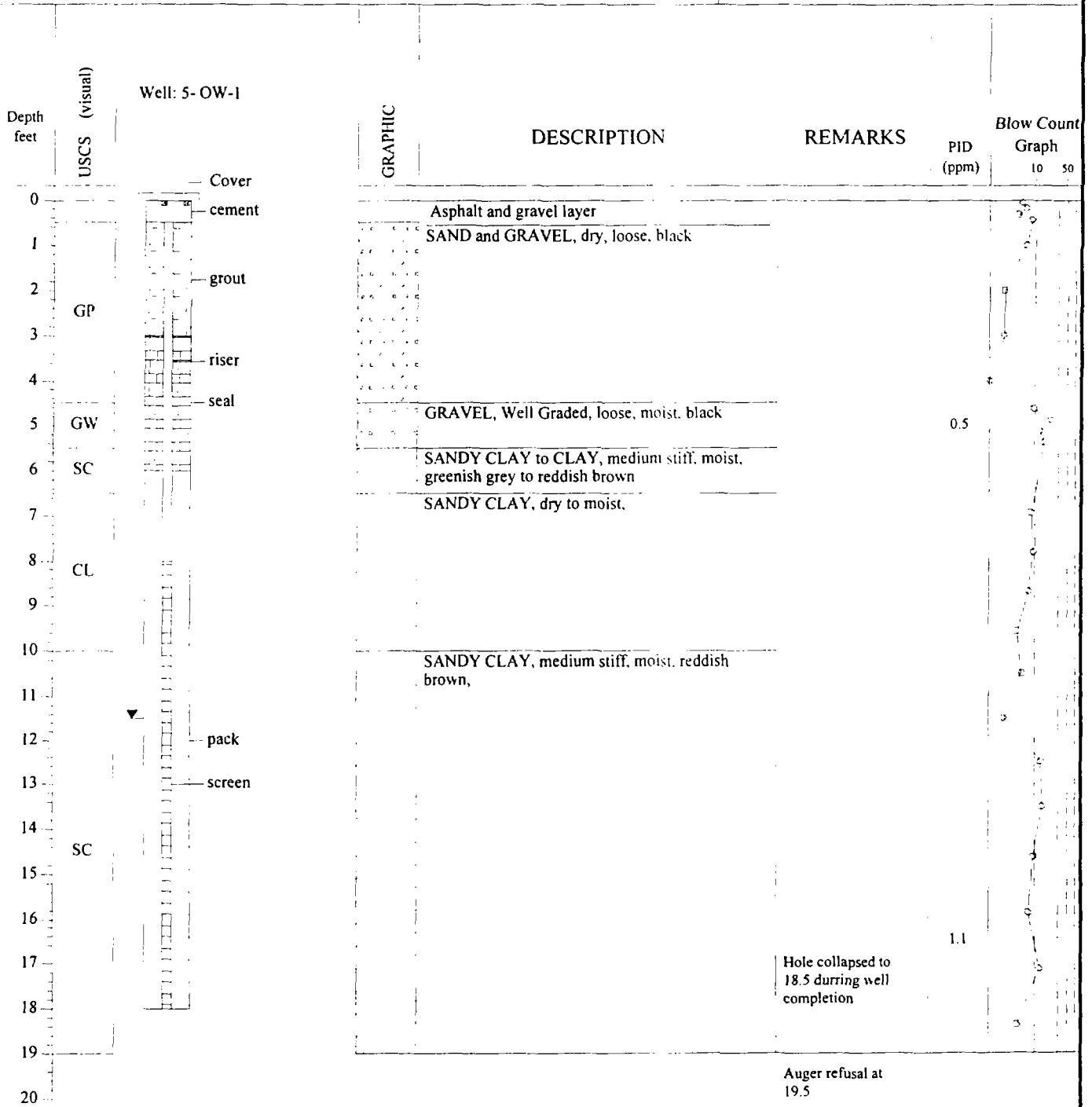
FIGURE 7

Skinner Landfill Work Group
ET Project Number: 38335.03

(Page 1 of 1)

Date Started : November 3, 1999
Date Completed : November 3, 1999
Project Name : Skinner Landfill Site
Project Location : Butler County,
West Chester, Ohio

Drilling Method : 8" hollow stem auger
Contractor :
Logged By : Jenny Downard



TABLES

TABLE 1

SKINNER LANDFILL REMEDIAL ACTION
MONITORING WELLS TO BE ABANDONED

Monitoring Wells to be Abandoned			
B-5	GW-17	GW-28	GW-50
B-8	GW-18	GW-29	GW-51
GW-9	GW-19	GW-31	GW-52
GW-10	GW-20	GW-32	GW-53
GW-11	GW-21	GW-33	GW-54
GW-12	GW-23	GW-35	GW-55
GW-14	GW-25	GW-36	GW-56
GW-15	GW-27	GW-38	GW-57

TABLE 2

SKINNER LANDFILL REMEDIAL ACTION
NEW GROUNDWATER MONITORING WELLS

Well Designator	Sampling Activity
GW-58	Groundwater Sampling
GW-59	Groundwater Sampling
GW-60	Groundwater Sampling
GW-61	Groundwater Sampling
GW-62A	Groundwater Sampling
GW-62B	Groundwater Sampling
GW-63	Groundwater Sampling
GW-64	Groundwater Sampling
GW-65	Groundwater Sampling
GW-66	Monitoring for DNAPLs

TABLE 3
SKINNER LANDFILL REMEDIAL ACTION
SAMPLING AND ANALYSIS PROGRAM SUMMARY

Sample Matrix (1)	No. of Samples	Field Dups. (2)	Field Blanks (2)	MS/ MSD (3)	Trip Blanks (4)	Total Samples	Test Parameters (5)
Soil	19	2	-	1	-	22	TCL PCBs, TCL PAHs, and TAL Lead. See Table 7 for parameters.
Re-evaluate/Confirm Baseline Surface Water Conditions (at SW-50, SW-51, SW- 52 & SW-53) unfiltered (7)	4	1	1	1	1	8	See Tables 8, 9, and 11 for parameters.
RA Construction Surface Water Monitoring, at SW-50, SW-51, SW-52, SW-53, & SW-54) unfiltered (6)	5	1	1	1	1	9	See Tables 8, 9, and 11 for parameters.
Surface Water Run-off Monitoring unfiltered (6)	3	1	1	1	1	7	See Tables 8, 9, and 11 for parameters.
Re-evaluate/Confirm Baseline Groundwater Monitoring Conditions, metals filtered and unfiltered (7)	11	2	2	1	1	17	See Tables 8, 9, and 11 for parameters.

- Notes:
- (1) All samples are considered low/medium environmental samples.
 - (2) For surface water and run-off sampling , one field duplicate and one field blank will be collected during each sampling event. For other sampling, one field duplicate and one field blank will be collected every 10 or fewer investigative samples.
 - (3) MS/MSD consists of extra volume collected for one of the investigative samples. They will be collected at the rate of one for each surface water and out-fall sampling event and at the rate of one for every 20 or fewer investigative samples for other media. (Triple ADDITIONAL volume for VOCs, double ADDITIONAL volume for SVOCs). Laboratory duplicate analysis must be performed on an aliquot from the original one liter (1L) investigative sample container; no extra volume is required.
 - (4) One trip blank will be included with each shipment of aqueous VOC samples.
 - (5) Field parameters will be collected for aqueous samples and may include temperature, pH, specific conductance, and dissolved oxygen.
 - (6) Surface water run-off sampling will be done monthly until completion of the RA cover and trench/cut-off wall system construction activities. Samples listed are per sampling event. Run-off samples will only be collected after a rain event.
 - (7) Surface water and groundwater samples will be collected at selected sample locations at the end of the RA construction activities to re-evaluate and confirm the baseline conditions defined during the GWDI.

TABLE 4
SKINNER LANDFILL REMEDIAL ACTION
PROPOSED MONITOR WELL AND PIEZOMETER SCREENED INTERVALS

Monitoring Well or Piezometer	Depth to Bottom of Well or Piezometer (ft)	Screened Length (ft)	Target Interval
GW-58	13	10	Sand and gravel
GW-59	12	10	Sand and gravel
GW-60	12	10	Sand gravel, bottom of trench, bedrock - sediment interface
GW-61	19	10	Sand, bottom of trench
GW-62A	15	10	Sand, bottom of trench
GW-62B	24	10	Bedrock - sediment interface
GW-63	19	10	Sand, bedrock - sediment interface
GW-64	13	10	Sand, bedrock - sediment interface
GW-65	14	10	Bedrock - sediment interface
GW-66	29	10	Bedrock - sediment interface
P-1	19	10	Sand and gravel, bottom of trench
P-2	17	10	Bedrock - sediment, interface
P-3	14	10	Sand
P-4	18	10	Sand, bedrock - sediment interface
P-5	13	10	Bedrock - sediment interface
P-6	40	15	Bottom of waste/Groundwater interface
P-7	40	15	Groundwater interface
P-8	40	15	Groundwater interface
P-9	40	15	Groundwater interface
P-10	40	15	Groundwater interface
P-11	55	15	Groundwater interface
P-12	50	15	Groundwater interface

TABLE 5

SKINNER LANDFILL REMEDIAL DESIGN
WATER SAMPLE BOTTLES, PRESERVATION AND TECHNICAL HOLDING TIMES

Parameters	Container	Preservative	Technical Holding Time	Amount
TCL Volatiles	40 mL VOA vials	HCl to pH<2 Cool, 4 degrees C	10 days	2 x 40 mL
TCL Semi-volatiles	1 L amber glass	Cool, 4 degrees C	5 days to extraction 40 days to analysis	2 x 1 L
TAL Inorganics (unfiltered/filtered)	1 L polyethylene	HNO ₃ to pH<2 Cool, 4 degrees C	180 days (except mercury 26 days)	1 L
TAL Cyanide	1 L polyethylene	NaOH to pH>12 Cool, 4 degrees C	12 days	1 L
BOD - EPA 405.1	1 L polyethylene	Cool, 4 degrees C	48 hours	1 L
TSS - EPA 160.2	1 L polyethylene	Cool, 4 degrees C	7 days	1 L
Oil & Grease - EPA 1664	1 L amber glass	H ₂ SO ₄ to pH<2 Cool, 4 degrees C	28 days	1 L
Ammonia Nitrogen - EPA 350.1	1 L amber glass	H ₂ SO ₄ to pH<2 Cool, 4 degrees C	28 days	1 L
TDS - EPA 160.1	250 ml polyethylene	Cool, 4 degrees C	7 days	250 mL

TABLE 6

SKINNER LANDFILL REMEDIAL ACTION
SOIL SAMPLE BOTTLES, PRESERVATION AND TECHNICAL HOLDING TIMES

Parameters	Container	Preservative	Technical Holding Time	Amount
TCL Semi-volatiles	8 oz clear glass	Cool, 4 degrees C	5 days to extraction 40 days to analysis	8 oz
TCL Pesticides/PCBs	8 oz clear glass	Cool, 4 degrees C	5 days to extraction 40 days to analysis	8 oz
TAL Inorganics - Lead	8 oz clear glass	Cool, 4 degrees C	180 days	8 oz

TABLE 7

SKINNER LANDFILL REMEDIAL ACTION
PARAMETERS AND REMEDIAL TRIGGER LEVELS FOR
CONTAMINATED SOILS EXCAVATION

CONTAMINANT	CONCENTRATION (mg/Kg) (1)
Polychlorinated Biphenyls - Total	0.160
Benzo(a)anthracene	0.330
Benzo(a)pyrene	0.100
Benzo(b)fluoranthene	0.330
Benzo(k)fluoranthene	0.330
Chrysene	0.330
Lead	500.0

- (1) The concentrations shown in this table are not detection limits. CRQLs for these parameters are shown in Tables 8 through 11.
Analytical Method: CLP SOW OLMO4.2

TABLE 8

SKINNER LANDFILL REMEDIAL DESIGN
TARGET COMPOUND LIST VOLATILES AND
CONTRACT REQUIRED QUANTITATION LIMITS

		Quantitation Limits
Volatiles	CAS Number	Water (ug/L)
1. Vinyl Chloride	75-01-4	10
2. 1,2-Dichloroethene (total) (1)	540-59-0	10
3. Chloroform	67-66-3	10
4. 1,2-Dichloroethane	107-06-2	10
5. 2-Butanone	78-93-3	10
6. 1,1,1-Trichloroethane	71-55-6	10
7. Carbon Tetrachloride	56-23-5	10
8. 1,2-Dichloropropane	78-87-5	10
9. Trichloroethene	79-01-6	10
10. 1,1,2-Trichloroethane	79-00-5	10
11. Benzene	71-43-2	10
12. Tetrachloroethene	127-18-4	10
13. Toluene	108-88-3	10
14. 1,1,2,2-Tetrachloroethane	79-34-5	10
15. Chlorobenzene	108-90-7	10
16. Ethyl benzene	100-41-4	10
17. Styrene	100-42-5	10
18. Xylenes (total)	1330-20-7	10

(1) Table 2 reports 1,2 - Dichloroethene (total) as 1,2 - Dichloroethene (cis) and 1,2 - Dichloroethene (trans).

TABLE 9

SKINNER LANDFILL REMEDIAL DESIGN
TARGET COMPOUND LIST SEMI-VOLATILES AND
CONTRACT REQUIRED QUANTITATION LIMITS

Semi-volatiles (2)	CAS Number	Quantitation Limits	
		Water (ug/L)	Soil/Sediment (mg/Kg) (1)
1. Phenol	108-95-2	10	330
2. bis(2-Chloroethyl) ether	111-44-4	10	330
3. 1,3-Dichlorobenzene	541-73-1	10	330
4. 1,4-Dichlorobenzene	106-46-7	10	330
5. 1,2-Dichlorobenzene	95-50-1	10	330
6. 2,2'-oxybis-(1-Chloropropane) (3)	108-60-1	10	330
7. Hexachloroethane	67-72-1	10	330
8. Nitrobenzene	98-95-3	10	330
9. Isophorone	78-59-1	10	330
10. 2,4-Dimethylphenol	105-67-9	10	333
11. 1,2,4-Trichlorobenzene	120-82-1	10	330
12. Naphthalene	91-20-3	10	330
13. Dimethylphthalate	131-11-3	10	330
14. Acenaphthene	83-32-9	10	330
15. 4-Nitrophenol	100-02-7	25	830
16. Phenanthrene	85-01-8	10	330
17. Di-n-butyl phthalate	86-74-2	10	330
18. Fluoranthene	206-44-0	10	330
19. Butyl benzyl phthalate	85-68-7	10	330
20. <u>Benzo(a)anthracene</u>	56-55-3	10	333
21. <u>Chrysene</u>	218-01-9	10	330
22. bis(2-Ethylhexyl)phthalate	117-81-7	10	330
23. <u>Benzo(b)fluoranthene</u>	205-99-2	10	330
24. <u>Benzo(k)fluoranthene</u>	207-08-9	10	330
25. <u>Benzo(a)pyrene</u>	50-32-8	10	330
26. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
27. Dibenzo(a,h)anthracene	53-70-3	10	330
28. Benzo(g,h,i)perylene	191-24-2	10	330

- (1) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the protocol, will be higher.
- (2) Underline parameters are the site specific parameters of interest defined in the ROD and RD SOW as listed in Table 3.
- (3) Previously known by the name bis(2-Chloroisopropyl) ether.

TABLE 10

SKINNER LANDFILL REMEDIAL DESIGN
TARGET COMPOUND LIST PESTICIDES & PCBs AND
CONTRACT REQUIRED QUANTITATION LIMITS

		Quantitation Limit
Pesticides/Aroclors	CAS Number	Soil (mg/Kg) (1)
1. AROCLOR-1016	12674-11-2	33.0
2. AROCLOR-1221	11104-28-2	67.0
3. AROCLOR-1232	11141-16-5	33.0
4. AROCLOR-1242	53469-21-9	33.0
5. AROCLOR-1248	12672-29-6	33.0
6. AROCLOR-1254	11097-69-1	33.0
7. AROCLOR-1260	11096-82-5	33.0

- (1) Quantitation limits listed for soil are based on wet weight. The quantitation limits calculated by the laboratory for soil, calculated on dry weight basis, as required by the protocol, will be higher.

TABLE 11

SKINNER LANDFILL REMEDIAL DESIGN
TARGET ANALYTE LIST INORGANICS AND
CONTRACT REQUIRED QUANTITATION LIMITS

Analyte (4)	Contract Required (1, 2, 3) Quantitation Limit (ug/L)
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Chromium	10
Copper	25
Iron	100
<u>Lead</u>	3
Mercury	0.2
Nickel	40
Selenium	5
Silver	10
Thallium	10
Zinc	20
Cyanide	10

- (1) Higher detection limits may only be used if the sample concentration exceeds five times the detection limit of the instrument or method in use. The value may be reported even though the instrument or method detection limit may not equal the CRQL. This is illustrated in the example where the value of 220 may be reported even though the instrument detection limit is greater than the CRQL.

For lead: Method in use = ICP
Instrument Detection Limit (IDL) = 40
Sample Concentration = 220
CRQL = 3

- (2) The CRQL's are the instrument detection limits obtained in pure water. The detection limits for samples may be considerably higher depending on the sample matrix.
- (3) The CRQL's for soils = 200 times CRQL's for water.
- (4) Underlined parameter is the site specific parameter of interest defined in the ROD and RD SOW as listed in Table 3.

APPENDIX I

EARTH TECH STANDARD OPERATING PROCEDURES

APPENDIX I

SOP TABLE OF CONTENTS

SOP-1	Well Purging
SOP-2	Groundwater Sampling
SOP-3	Containment and Disposal of Investigation Derived Waste
SOP-4	Standard Operating Procedure for the Field pH Measurement
SOP-8	Surface Water Sampling
SOP-9	Soil Sampling from Excavations

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on well purging by the pumping method prior to the sampling of groundwater wells. The methods and equipment described are for the purging of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure applies to purging relatively large volumes of water in shallow to medium depth wells.

3.0 REQUIREMENTS

Methods for purging from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant.

4.0 REFERENCES

4.1 United States Environmental Protection Agency, 1989. *Groundwater Handbook*: EPA/625/6-87/016.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Project Manager

The Project Manager is responsible for reviewing the purging procedures used by the field crew and for performing in-field spot checks for proper purging procedures.

6.2 Site Geologist

The Site Geologist is primarily responsible for the proper well purging techniques. The Geologist will be responsible for purging of wells, performing necessary physical measurements and observations, and containment of purged water. He must record pertinent information including amount of water purged, pH, specific conductivity, temperature, and turbidity in the Field Log Book.

7.0 EQUIPMENT

1. Purge pump.
2. Power source.
3. Bailers (stainless steel and/or Teflon™)
4. Steel retractable engineer's measuring tape (Calibrated to 0.01 foot)
5. Water level indicators.
6. Swabbing equipment (as necessary).
7. pH meter.
8. Specific conductance meter.
9. Thermometer.
10. HNu photoionization detector.
11. Containers for the development water.
12. Field log book.

8.0 PROCEDURE

8.1 General

- The amount of flushing a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions.
- For the volumetric method, generally three well volumes are considered effective for purging a well.
- An alternative method of purging a well is to purge continuously (using a low volume low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize.

8.2 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to determine the volume of standing water in the well pipe and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).
2. Determine well or casing and diameter.
3. Measure and record static water level (Depth below ground level or top of casing reference point).
4. Determine depth of well.
5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
6. Calculate the volume of water in the casing.

$$V_t = \pi (d_i/2)^2 (TD-H) (7.48)$$

Where:

$P_i = 3.14$

$V_t =$ Total volume, gal

$d_i =$ inside diameter of casing, ft

$TD =$ total depth of well, ft

$H =$ depth to water, ft, from ground surface

7. Determine the minimum number of volumes to be evacuated before sampling.

8.3 Well Purging by Pumping

- Lower the purge pump into the well until it is submerged. NOTE!!!: If resistance is encountered when lowering the pump into the well, WITHDRAW THE PUMP FROM THE WELL and inform the Field Team Leader.
- Direct the pump discharge hose into the receptor bucket and start the pump in accordance with the manufacturer's operations manual.
- Record total volume of water removed.
- Collect at least three samples during purging and measure physical parameters including pH, conductivity, and temperature.
- Whenever the receptor bucket is full, dispose of the purge water in accordance with the procedures specified in the IRM QAPP for the Skinner Landfill.
- Purging will continue until the required volume of water has been removed and the physical parameters have stabilized so that pH is ± 0.1 su, conductivity ± 10 umhos, temperature is $\pm 1^\circ\text{C}$, within three successive intervals.
- Decontaminate the bailers per the project-specific work plan.

8.4 Purging with Bailers

- Standard-cleaned Teflon™ bailers with Teflon™ leaders and new nylon rope are lowered into top of the water column, allowed to fill, and removed.
- Record total volume of water removed.
- Collect at least three samples during purging and measure physical parameters including pH, conductivity, and temperature.
- Whenever the receptor bucket is full, dispose of the purge water in accordance with the procedures specified in the IRM QAPP for the Skinner Landfill. The water is either discarded or contained and managed as investigation derived waste

- Purging will continue until the required volume of water has been removed and the physical parameters have stabilized so that pH is ± 0.1 su, conductivity ± 10 umhos, temperature is $\pm 1^\circ\text{C}$, and turbidity less than 10 NTUs within three successive intervals.
- It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize disturbance of volatile organic constituents.
- Decontaminate the bailer per the project-specific work plan.

8.5 Purge Water Containment and Disposal

Purge water will be contained and disposed as detailed in SOP-3.

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to obtain groundwater samples that are representative of the source from which they are taken and minimize sampler exposure to groundwater contaminants. The methods and equipment described are for the collection of water samples from the saturated zone of the substrata.

2.0 SCOPE

This procedure provides information on proper equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific work plans may require adjustments in methodology.

3.0 REQUIREMENTS

Generally, wells should be sampled within three hours of purging. However, wells with poor recharge should be sampled within 24 hours of purging. Poor recharge wells are those that cannot recharge 80% of the original volume within 8 hours.

Applicable preservatives must be added to the sample containers before the samples are collected.

4.0 REFERENCES

- 4.1 ASTM, 1986. *Annual Book of ASTM Standards*, Section 11. Volume 11.04, D4448-85A.
- 4.2 Barcelona, M.J., J.P. Gibb and R.A. Miller, 1983. *A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling*, ISWS Contract Report 327, Illinois State Water Survey, Champaign, IL.
- 4.3 Johnson Division, UOP, Inc., 1975. *Groundwater and Wells, A Reference Book for the Water Well Industry*. Johnson Division, UOP, Inc., Saint Paul, MN.
- 4.4 Nielson, D.M. and G.L. Yeates, 1985. *A Comparison of Sampling Mechanisms Available for Small-Diameter Groundwater Monitoring Wells*. Groundwater Monitoring Review 5:38-98.
- 4.5 Scalf, M.R., J.F. McNabb, W.J. Dunlapp, R.L. Crosby and J. Fryberger, 1981. *Manual of Groundwater Sampling Procedures*. R.S. Kerr Environmental Research Laboratory, Office of Research and Development, USEPA, Ada, OK.
- 4.6 USEPA, 1980. *Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities*. Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.
- 4.7 USEPA, 1986. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA SW-846.
- 4.8 USEPA, 1987. *Groundwater Handbook*, EPA/625/6-87/016.
- 4.9 USEPA, 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Project Manager

Responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

6.2 Site Geologist

The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples.

7.0 EQUIPMENT

Sample containers shall conform with U.S. EPA regulations for preservation of appropriate contaminants.

Ideally, sampling equipment should be completely inert, economical, easily decontaminated, easily sterilized, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection. The sample withdrawal equipment (evacuation devices) to be used on this project are submersible pumps or bailers. Other equipment to be used include:

1. Sample Packing and Shipping Equipment.
2. Coolers for sample shipping and cooling.
3. Chemical preservatives.
4. Appropriate packing cartons and filler.
5. Labels.
6. Chain-of-custody documents.
7. Thermometer.
8. pH meter.
9. Portable HNu photoionization detector.
10. Specific conductivity meter.
11. Water-level indicator.
12. Flow meter.
13. Field sampling logbooks.
14. Pails.
15. Gamma and Beta Radiation Detector.

8.0 PROCEDURE

8.1 General

To be useful and accurate, a groundwater sample must be representative of the particular saturated zone of the substrata being sampled. The physical, chemical and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells. The ASTM guide is not intended as a monitoring plan or procedure for a specific application, but rather as a review of methods.

The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well, and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing. Stratification may occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be purged prior to withdrawing a sample. Evacuation of three volumes is recommended for a representative sample. Purge water will be contained and disposed as detailed in SOP-3, Section 8.1.
2. For wells that can be purged dry, the wells should be evacuated and allowed to recover prior to sample withdrawal.
3. For high-yield monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. The use of a pump and certain techniques of sample withdrawal may minimize this possibility.

Stratification of contaminants may exist in the groundwater either in terms of concentration gradients as a result of mixing and dispersion processes in a homogeneous layer, or due to layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point. This can result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Purge water will be disposed in accordance with the procedures specified in the IRM QAPP for Skinner Landfill.

8.2 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well casing and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method. Calculations should be entered into the field logbook:

1. Obtain the available information on well construction (location, casing, screens, etc.).
2. Determine well or casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point).
4. Determine depth of well.
5. Calculate number of linear feet of static water (total depth or length of well casing minus the depth to static water level).
6. Calculate the volume of water in the casing.

$$V_t = \pi (d_i/2)^2 (TD-H)(7.48)$$

Where,

$P_i = 3.14$

V_t = Total volume, gal

d_i = inside diameter of casing, ft

TD = total depth of well, ft

H = depth to water, ft, from ground surface

7. Determine the minimum number of volumes to be evacuated before sampling.

8.3 General

The amount of flushing a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped sufficiently to remove the stagnant water but not long enough to induce significant groundwater.

8.4 Sampling

8.4.1 Sampling Methods

The collection of a groundwater sample is made up of the following steps.

1. Record the sample location, site, anticipated sample time, and field sample number using an indelible pen. Fill out sample labels for each of the required sample containers and place labels onto the appropriate sample containers. Labels must be waterproof to prevent water damage. The following information may be included on the sample label:
 - site name;
 - field identification or sample station number;
 - date and time of sample collection;
 - type of sample (matrix) and a brief description of the sampling location;
 - printed full name of the sampler;
 - sample preservative used; and
 - types of analyses to be performed.

If a sample is split with another party, sample labels with identical information should be attached to each of the sample containers.

2. Open the well cover and use volatile organic detection meter (HNU) to monitor the escaping gases at the well head to determine the need for respiratory protection.
3. Sound the well for total depth and water level (using decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well.

4. Calculate depth from the casing top to the midpoint of the screen or well section open to the aquifer. Any dry wells encountered must be noted.
5. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection may be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.
6. To ensure that groundwater samples are representative of actual conditions, samplers must work efficiently to minimize the loss of groundwater contaminants and the introduction of foreign contaminants. To prevent contamination of samples, the sample bottles should be opened only when receiving sample preservatives or groundwater samples and closed immediately afterwards.

The sampler should quickly add the sample into the sample containers, while minimizing aeration and loss of volatile contaminants. Samples collected for analysis of volatile constituents will be collected first, followed by samples collected for analysis of SVOCS, pesticides/PCBs, metals, and cyanide. Additional water from the well will be divided among the remaining sample bottles. For analysis that requires filtered samples, it is preferred that the samples be allowed to settle in a separate sample container, followed by decanting and then filtration. Field filtration may also be accomplished using an in-line filter. Consult the specific analytical procedure for details. Large volume samples for extractable organic compounds, total metals, etc., should be collected last.

When a sample bottle is filled, the bottle must be tightly capped as soon as possible.

7. Efficiency and care must be utilized to obtain representative samples for volatile organic analysis. Unnecessary delays or poor sampling technique will lead to loss of the volatile constituents from the sample.

Add the required preservatives to the sample containers immediately prior to or after collecting the sample, label all containers and stage the collection setup before collecting the sample to minimize sampling time.

Prevent unnecessary stripping of volatile constituents from the sample by minimizing turbulence and aeration when filling the sample container. Quickly fill the sample container until a positive meniscus is achieved above the rim of the container and cover the container immediately. Gently tap the sample container to dislodge any air bubbles and verify that no bubbles are present. If bubbles are detected, a new VOA vial should be filled and should then be checked to verify that no bubbles are present. Repeat this step until the sample contains no bubbles and all required samples are obtained.

8. After sampling, replace the well cover.
9. As soon as all samples are collected, promptly prepare the samples for shipment in accordance with the FSP, and store the samples collected for volatile organic analysis in a cooler with pre-packaged ice. Attach a custody seal to the shipping package as described in the FSP. Make sure that the chain-of-custody forms are properly filled out and enclosed or attached.

10. Record all sampling information in the field log book.

11. Decontaminate all equipment.

8.4.2 Sample Containers

Use the laboratory-supplied sample containers which are pre-cleaned and appropriate for the analytical method for which you are sampling.

8.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. The Skinner Landfill QAPP describes the sample preservation and volume requirements for the chemicals that will be analyzed.

8.4.4 Field Filtration

All filtration must occur in the field immediately upon collection. Filters must be pre-rinsed with organic-free water.

Samples for organic analyses must never be filtered.

8.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If natural ice is used, it should be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and possibly cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage.

8.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in Table 6.

8.5 Records

Records will be maintained for each sample that is taken. Record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (analyses to be run; number and size of bottles; preservatives added).

- Additional remarks - (e.g., sampled in conjunction with regulatory authorities; samples for specific conductance value only; samples for key indicator; etc.).

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to define the methods to be followed to contain and dispose of Investigation Derived Wastes (IDW) to prevent runoff from IDW from impacting any surface waters.

2.0 SCOPE

Investigation Derived Waste will be generated during purging of monitoring wells for development and for sampling, during decontamination procedures occurring on site, and during drilling operations. This SOP should be consulted during any of the above procedures to ensure that the proper precautions are taken.

3.0 REQUIREMENTS

It is important to ensure that the surface waters located on and near the site are not impacted by Investigation Derived Waste.

4.0 REFERENCES

None.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Field Team Leader

The Field Team Leader is primarily responsible for ensuring that the proper procedures are followed to contain and dispose of Investigation Derived Waste. He is responsible for training the field personnel in the proper procedures for the individual tasks.

6.2 Field Geologist

The Field Geologist will be responsible for documenting the disposition of all Investigation derived waste in the field logbook.

7.0 EQUIPMENT

1. Drums.
2. Other containers as appropriate.
3. Personnel protective equipment as needed.

8.0 PROCEDURE

Three field procedures are expected to generate Investigation Derived Waste; purging and development of monitoring wells, decontamination of field equipment, and drilling operations.

8.1 Purge and Development Fluids

Prior to emplacement of the landfill cap, fluids generated during purging or development of monitoring wells will be containerized at the well site transported to the top of the landfill and deposited on the ground surface of the landfill (see Figure 2). Any fluids generated after cap emplacement will be containerized for off-site disposal.

8.2 Decontamination Water

The decontamination zone will be located on top of the landfill. Heavy equipment will be decontaminated there. Bailers, split spoons and other small sampling devices may be decontaminated at the work site as long as the decontamination water is containerized, transported to the decontamination zone and deposited on the ground surface of the landfill. Decontamination fluids generated after the emplacement of the landfill cap will be containerized for off-site disposal.

8.3 Drill Cuttings

Drill cuttings will be drummed at the drill site and transported to the drum storage area located on top of the landfill. The drummed waste will later be incorporated beneath the cover during the RD.

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for surface water sampling.

2.0 SCOPE

Surface water sampling is applicable to almost any site that has surface drainage on it or at any location located hydraulically downgradient from the site.

3.0 REQUIREMENTS

Many factors must be considered in developing a sampling program for surface water including study objectives; accessibility; site topography flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water.

4.0 REFERENCES

- 4.1 Feltz, H.R., 1980. *Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments*. Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., V.i, p. 271-287.
- 4.2 Kittrell, R.W., 1969. *A Practical Guide to Water Quality Studies of Steams*. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135 p.
- 4.3 USEPA, 1980. *Standard Operating Procedures and Quality Assurance Manual*. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, GA.
- 4.4 US Geological Survey, 1977. *National Handbook of Recommended Methods for Water-Data Acquisition*. Office of Water Data Coordination, USGS, Reston, VA.

5.0 DEFINITIONS

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling as a high hazard sample.

6.0 RESPONSIBILITIES

6.1 Field Geologist

The Field Geologist has overall responsibility for the correct implementation of surface water sampling activities, including review of the Field Sampling Plan.

7.0 EQUIPMENT

- 1. Sampling bottles treated with preservatives if necessary.
- 2. Specific conductivity meter.
- 3. pH meter.
- 4. Thermometer.
- 5. D.O. meter.

6. Beta-gamma radiation meter.
7. Dip sampler.
8. Weighted bottle sampler.
9. Hand pump.

8.0 PROCEDURE

The following section outlines commonly used procedures for collecting surface water samples. Surface water sampling will begin at the most downstream location and proceed progressively to the upstream locations. It is anticipated that Dip Sample will be used to collect surface water samples during the RA.

8.1 Water Sampling Techniques

8.1.1 Dip Sampling

Water is often sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water column and in the cross section.

8.1.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed and returned to the surface. This allows discrete sampling with depth. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface.

A closed weighted bottle sampler consists of a stoppered glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and to lower or raise the bottle. The procedure for sampling is:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
2. Pull out the stopper with a sharp jerk of the sampler line.
3. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
4. Raise the sampler and cover the bottle.
5. Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as the original bottle is an approved container).

8.1.3 Hand Pumps

Hand pumps may be operated by peristaltic, bellows, diaphragm, or siphon action. Hand pumps which operate by a bellow, diaphragm, or siphon action should not be used to collect samples which will be analyzed for volatile organics because the slight vacuum applied may cause loss of these contaminants.

Tubing used for the inlet hose should be nonreactive (preferably Teflon). The tubing and liquid trap must be thoroughly decontaminated between uses (or disposed of after one use).

When sampling, the tubing is weighted and lowered to the desired depth. The sample is then obtained by operation of the pump and subsequently transferred from the trap to the sample container.

9.0 ATTACHMENTS

None.

1.0 PURPOSE

The purpose of this procedure is to define the methods to be followed when collecting soil samples from excavations or trenches.

2.0 SCOPE

Soil samples will be collected from excavations created by the removal of contaminated soil or "hot spots". This SOP should be consulted during any of the above procedures to ensure that the proper procedures are followed.

3.0 REQUIREMENTS

Sampling is being conducted to confirm that impacted soil has been excavated from the "hot spot" locations.

4.0 REFERENCES

None.

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

6.1 Field Team Leader

The Field Team Leader is primarily responsible for ensuring that the proper procedures are followed for collecting the soil samples. He is responsible for training the field personnel in the proper procedures for the individual tasks.

6.2 Field Geologist

The Field Geologist will be responsible for the correct implementation of soil sampling activities involving excavations, including review of the Field Sampling Plan.

7.0 EQUIPMENT

1. Pre-cleaned sample containers.
2. Tape measure.
3. Backhoe.
4. Stainless steel scoop.
5. Personnel protective equipment as needed.
6. Sample labels and cooler.

8.0 PROCEDURE

The following section describes the procedures to be used for sample collection, sample handling and additional excavation if obtained samples do not meet clean-up standards.

8.1 Sample Collection

Each sample will be collected from a discrete location with the sampling point located relative to a permanent, immovable object. The sample depth will be measured from the ground surface to the sampling point using a tape measure. The sample will be obtained from the sampling point using a backhoe bucket.

The bucket will be brought to the surface and away from the sides of the excavation so the field geologist can access the bucket without entering the excavation or standing near the edge of it. The sample will then be removed from the soil in the center of the backhoe bucket using a decontaminated stainless steel scoop.

The soil sample will be transferred to a pre-cleaned, laboratory-supplied sample bottle. The backhoe bucket and trowel will be decontaminated between samples in accordance with Section 6.3 of the Field Sampling Plan.

8.2 Sample Handling

Personnel will collect samples while wearing new latex or nitrile gloves. The full sample containers will be labeled and immediately placed in a secure cooler with ice. Sample custody and documentation will be conducted in accordance with Section 5.0 of the QAPjP. Samples will be shipped to the laboratory the same day they are collected.

8.3 Sample Location and Additional Excavation

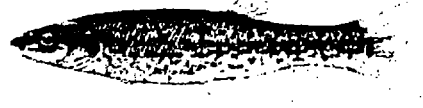
Samples will be collected from the side walls and bottom of the excavations in the locations shown on Figures 2 and 3 of the Field Sampling Plan. Sample depth on the side wall will be half way between the ground surface and the bottom of the excavation. The expected depth to the bottom of the excavation is 7.5 ft.

Should the initial soil samples indicate a failure to meet clean-up standards, additional excavation will be conducted three ft in the direction of the detected contamination. This distance may be increased based on the magnitude of the contaminant concentration.

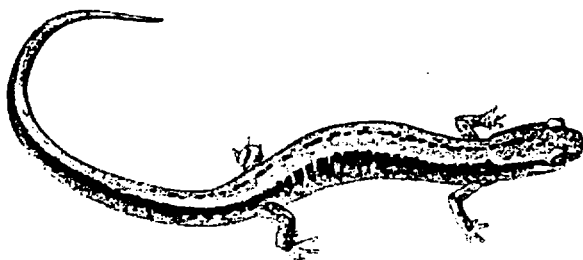
APPENDIX II

**Primary Headwater Habitat Assessment Program
Ohio EPA, DSW**

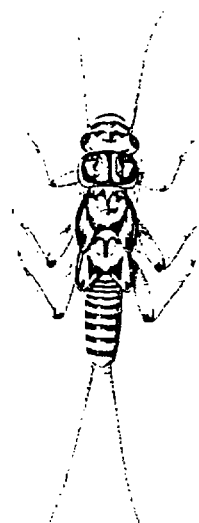
Primary Headwater Habitat Assessment Program Field Evaluation Manual



Blacknose Dace



Two-Lined Salamander



Stonefly larva

Ohio EPA Division of Surface Water
P.O. Box 1049
Columbus, Ohio 43216-1049

June, 1999

[DISCLAIMER: This document is a final draft working copy manual produced by the Ohio EPA as a tool to promote standardized biological assessment of headwater streams in Ohio and does not represent an officially sanctioned methodology, policy or regulation of the Ohio Environmental Protection Agency. Upon further use and testing the Ohio Environmental Protection Agency may consider inclusions of these methods in "Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices" (Ohio EPA, 1989), as well as possible revisions to aquatic life use designations found in Rule 3745-1-07 of the Ohio Administrative Code. Questions regarding the State's water quality standard regulations and aquatic life use designations should be directed to the Division of Surface Water, PO Box 1049, Columbus OH 43216-1049 (614-644-2876). This document will continue to be updated as necessary throughout the life of the Primary headwater habitat Assessment Program]

Acknowledgements:

This document was prepared by the Paul Anderson, Robert Davic and Steve Tuckerman, DSW, NEDO. The contributions of other members of the Headwater Habitat Stream Work-Group is greatly appreciated, especially Bill Schumacher for his tireless coordination efforts. Other members of the work-group include Dan Dudley, Ed Rankin, Mike Bolton and Chris Yoder.

INTRODUCTION and RATIONALE:

The Federal Clean Water Act (Sec. 101 a) states that it is the objective of the Act to "... maintain the ... biological integrity of the Nation's waters", a goal that clearly applies not only to large rivers but also to the smaller headwater streams of the Nation's watersheds. The Ohio EPA has developed biological criteria to work in concert with chemical and physical criteria for identifying and protected various aquatic life uses of water bodies in the state (Ohio EPA, 1989). These criteria rely upon the assessment of fish and benthic macro-invertebrate communities and comparison via indices to un-impacted ecoregional reference sites. These biological indicators are excellent for the assessment of the majority of streams in the state with perennial flows and with the physical habitat to support fish, and have been tailored to various stream sizes in each ecoregion, including headwater streams with drainage areas less than 20 mi². However, it has been found that in smaller headwater streams, which we designate as "primary" headwater streams (generally with watershed areas less than 1-3 mi²), hydrology or other physical features such as lack of deep pools may limit the stream's ability to support resident fish communities. In these situations, it is impossible under the current regulations to define appropriate aquatic life use designations, even for un-impacted natural streams. The purpose of the primary headwater habitat study governed by this manual is to document the biological and physical features associated with the various types of headwater habitats found in the state and to provide the scientific basis for a potential rule making to establish new aquatic life criteria for these streams in Ohio.

The Ohio EPA headwater habitat stream work-group currently feels that three main types of primary headwater habitat stream types exist which can be defined. The highest quality, or *Class A* primary headwater habitat streams (herein referred to as PHWH), are those lotic ecosystems that have the potential to support high quality vertebrate and benthic macro-invertebrate aquatic communities, have diverse habitat, and are often spring fed with water flowing on an annual basis. By definition, PHWH streams have drainage areas less than 3 mi², and the vertebrate predator functional group is represented by either headwater fish populations and/or amphibians. Stream salamanders, mostly from the lungless family Plethodontidae, often replace fish as the dominant vertebrate predator functional group in these small lotic ecosystems. The second type of headwater stream habitat, designated the *Class B* PHWH, provides an environment which can support a high quality aquatic benthic macro-invertebrate community but is unable to support reproducing populations of fish or amphibians either as the result of intermittent flow conditions or physical limitations (substrate, gradient, lack of deep pools etc.). The third type of headwater drainage, designated here as *Class C* PHWH stream are lower quality headwater streams which do not provide a significant aquatic life function, but which do have important water quality functions. These streams may sometimes meet the definition of Limited Resource Waters (LRW) or may be given their own classification under the PHWH hierarchy. These streams have

little or no potential to support well balanced biological aquatic communities with recovery precluded by natural background conditions (i.e. lack of seasonal flow), or irretrievable human-induced conditions (i.e., regular flood control channel modification, dredging).

It is the purpose of this manual to outline a sampling protocol that can be used to provide the baseline data needed to distinguish between the three types of PHWH streams based upon biological and physical characteristics. Data gathered and compiled during this effort will be used to develop recommendations for new aquatic life use designations, refine field evaluation protocols, and to develop screening tools which can be utilized to make regulatory decisions regarding PHWH streams.

It should be noted that procedures for evaluating PHWH streams should only be conducted after it has been determined that the stream in question has no possibility of supporting a well balanced fish community and that other use designations for the stream (WWH, EWH, or CWH) are not appropriate. As a rule of thumb, any stream with a watershed area greater than 3 mi² or which has pools with maximum depths over 40 cm should be excluded from this study.

METHODS AND PROCEDURES

The primary headwater habitat evaluation process consists of both a physical and biological characterization of the stream segment. Data collected during this process is recorded on the Ohio EPA Primary Headwater Habitat Evaluation Form included as Attachment 1 of this manual. This section provides a list of the materials needed and outlines data collection procedures for completing the evaluation form and the procedures for conducting the biological assessment. Field personnel conducting these assessments should be sure to obtain permission for stream access and any necessary permits for conducting biological collections prior to conducting the assessment.

I. Equipment

An equipment checksheet for physical and biological measurements is included as Attachment 2 of this manual.

II. Reference materials

Reference for conducting the physical stream measurements outlined in the evaluation form can be found in Rosgen (1996) and Rankin (1989). Recommended reference materials for macro-invertebrate taxonomic identifications to Order or Family level of identification are Merritt and Cummins (1996), Pennak (1989). Salamanders should be identified to the genus level for this protocol using "The Salamanders of Ohio"

(Pfingsten and Downs, 1989). Species level identification of adult and larvae salamanders is possible using this reference as well. Excerpts from this resource, including dichotomous keys for the identification of adult and larval salamanders found in Ohio is included as Attachment 3 of this manual. A helpful field guide for macro-invertebrates (Lathrop, date unknown) is included as Attachment 4 to this manual. Attachment 5 of the manual consists of a guide to invertebrate taxonomic groups prepared by the Ecological Assessment Unit, DSW, Ohio EPA.

III. Physical Data and Measurements

1. Site Selection:

For sites of particular interest (e.g. 401 application sites, etc.), the zone to be evaluated should be representative of the area of best habitat within the proposed area of impact. For other sites, areas of habitat which appear to be representative of the stream segment being evaluated should be chosen. Areas of recent impact should be avoided.

2. QHEI Evaluation:

A Qualitative Habitat Evaluation Index (QHEI) sheet should be completed for each site in accordance with standard Ohio EPA procedures (Rankin, 1989). Many of the metrics used in the QHEI evaluation are important in the evaluation of headwater habitats.

For purposes of the QHEI evaluation, the headwater protocol utilizes a 200 foot zone for the evaluation of biological attributes and either a 100 foot or 200 foot zone for the analysis of physical attributes. The stream drawing on the QHEI sheet should cover the entire 200 foot zone, and should be of a level of detail to note significant channel and bank features.

3. Photographs:

Photographs should be taken of the area sampled for the presence of salamanders and of the stream segment utilized for stream channel measurements taken to complete section D of the Primary Headwater Habitat Evaluation Form. Photographs (and, if possible, negatives) should be submitted along with the completed Primary Headwater Habitat Evaluation Form.

4. **Primary Headwater Habitat Stream Evaluation Form:**

The purpose of the primary headwater habitat evaluation form is to provide site specific biological information regarding headwater habitats throughout the state. Additional physical data regarding stream characteristics will also be compiled for evaluation of important habitat features which govern headwater aquatic communities of aquatic organisms. It should be noted that many of the headwater streams in Ohio dry up for a significant period of the year. Therefore, complete biological evaluations of all of the stream segments to be evaluated may not be necessary. However, understanding the physical characteristics of these streams is necessary, and evaluation of a representative number of these types of streams is important to the overall headwater stream assessment program.

An additional set of data which is extremely important and which should be recorded throughout the evaluation process is the amount of time necessary to complete each portion of the evaluation. These data will be useful when developing a final screening tools for headwater habitats.

COMPLETED FORMS, PHOTOGRAPHS AND BIOLOGICAL SAMPLES SHOULD BE SUBMITTED TO ROBERT DAVIC AT OHIO EPA, 2110 East Aurora Road, Twinsburg, Ohio 44087. (330) 963-1132. robert.davic@epa.state.oh.us

III. INSTRUCTIONS FOR COMPLETING THE PRIMARY HEADWATER HABITAT STREAM EVALUATION FORM:

Form introduction: provide information regarding the date, team members and site name.

A. Stream Information (page 1):

Provide the information as indicated on the form for items 1-4.

Item A5: Information should be provided with enough specifics to allow for a return to the site at a later time. Headwater streams of the type covered by this survey often do not appear on USGS topographic maps and cannot be easily identified using river mile nomenclature. Location information utilizing landmarks, etc. may be necessary in order to re-locate the site at a later time.

Item A6: Circle the appropriate ecoregional location of the stream segment being evaluated.

Item A7: Using a 7.5 minute series USGS topographic map, determine the upstream drainage area for the stream segment under investigation. It is very possible that the stream will not be identified at this 1:24000 mapping scale, in which case it will be necessary to determine stream length by connecting elevation contour lines. Record drainage area in square miles. Also consult SCS (new NRCS) county soil maps. These maps often show very small headwater streams with drainage areas less than 1.0 sq. mi. Locate the study site on the soil map, if possible, and attach a copy to the evaluation form.

If the drainage area is greater than three square miles, or pools greater than 40 cm in maximum depth are present, the stream should be evaluated for use attainment for other aquatic life use designations (WWH, EWH, CWH) using Ohio EPA standardized biological and habitat (QHEI) field methods (Ohio EPA Biological User Manual, 1989) and use attainability procedures. For the purposes of this study, survey sites should be restricted to streams whose upstream watershed area is known to be three square mile or less.

Item A8: if a GPS unit is not available, latitude and longitude should be estimated from a 7.5 minute series USGS topographic map.

B. Riparian Zone Information (page 1):

Item B1. Include abbreviations of up to three of the soil types found along the stream according to the NRCS soils map. Where more than three exist, record those which appear most prevalent by area.

Item B2. The amount of open area in the canopy should be estimated as that which would be experienced at the time of maximum leaf cover.

Items B3 and B4. Record up to five dominant trees and types of under story vegetation found within the riparian zone of the stream segment being evaluated.

C. Flow Characteristics/Water Chemistry (page 2):

Item C1: The following definitions apply for apparent flow characteristics:

Permanent (or perennial) streams have flow year-round or for most times in any year.

Interstitial streams are those where surface flows may cease in many summers (especially in runs and riffles), but where pools remain connected by subsurface flows.

Intermittent streams are those that have some water in pools, but where surface and subsurface flows are low to non-existent during extended periods (typically in summer).

Ephemeral streams are those which are completely dry for at least some period every year.

Item C2. Stream flow in ft/sec should be estimated using either a flow meter or a float timed over a known distance. Record whether the stream appears to be at base flow at the time of sampling by circling the appropriate response. **NOTE: if the stream flow is elevated due to recent precipitation, the stream assessment should be postponed until it has returned to near base flow conditions.**

Item C3. Conduct field measurements for dissolved oxygen, pH, water temperature, and conductivity using standard Ohio EPA procedures. Temperature is potentially of critical importance in future evaluations of the applicability of cold water habitat use designations.

Item C4. Water samples for the analysis of other parameters will normally not be collected for this program. However, in the event that upstream chemical pollution of the water is suspected, a sample should be collected for analysis in order to ensure that site biology is not affected by water chemistry. If a sample is collected, provide the sample identification information and provide copies of the analytical report to the headwater habitat committee when available. In general, under these circumstances, analyses should be conducted for nutrient parameters (ammonia-N, nitrate+nitrite-N, total phosphorus), COD, chlorides, heavy metals, and fecal coliform bacteria.

Item C5. Check the appropriate box which indicates the appropriate downstream (within 2 RM) designated uses. Check a box only if the stream segment evaluated feeds to a wetland or to a stream with a known use designation or a stream for which a use attainability analysis has been conducted. If the stream segments downstream are un-designated, check no boxes, but describe downstream characteristics in the space provided for responses to item 7.

Item C6. Please be specific in responses to this item! Information provided in this section will be used to evaluate potential beneficial uses of the water body and to evaluate potential impacts on downstream uses. A description of the drainage hierarchy downstream of the segment being analyzed to the nearest named stream should be provided if possible.

D. Stream Channel Characteristics (page 3):

Important Note: It is important to complete the biological characterizations of the stream before conducting the stream physical measurements because the in-stream work needed necessarily causes turbidity in the stream.

In order to determine the stream channel characteristics being collected in the assessment, a decision must first be made whether to evaluate one or two 100 foot stream segments. For this study, the second 100 foot zone for stream measurements can be eliminated only if there is uniformity in stream gradient, flood plain and bank characteristics, and sinuosity throughout the 200 foot zone. If these conditions exist, elimination of the second 100 foot zone is warranted and will save considerable time. Best professional judgement should be used based upon an initial visual survey of the stream. If in doubt, the full 200 feet should be evaluated.

The 100 or 200 foot zone of the stream channel is then measured by first positioning a marker flag or rod at the upper end of the zone to be evaluated. Begin measuring by laying the end of the 100 foot tape measurer at the marker and proceed downstream, laying the tape in the deepest portion of the channel along the segment. When 100 feet of stream channel is measured out, position a second marker flag or rod at this location (the mid-point location). If a 200 foot zone is needed, repeat this procedure for the next 100 foot stream segment until the lower end of the 200 foot segment is marked.

Pick a single location within each 100 foot zone where stream channel width measurements will be taken (see discussion below for methods of selecting these locations). Note: if only one 100 foot section is evaluated, only one representative location for stream channel width measurements is selected.

Criteria for evaluating two vs. One 100 foot zones for channel characteristics:

Items D1, D2, D3, and D4. See Figures 1 and 2 for guidance as to the definition of terms.

Items D1 and D2

Bankfull (see Fig. 1): The measurement of bankfull widths and depths is an important defining tool for stream channel characteristics which have direct relationship to the ability of the stream to support aquatic organisms. The relationship of bankfull width, bankfull depth, floodprone width, gradient, and sinuosity to each other allows for the comparison of channel and stream types and for the classification of streams. The stream channel characteristics should be measured in riffle areas (or in a glide in the absence of riffles). A relatively straight stream segment should be selected which is not affected by the deposition of debris.

Definition:

"The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels." Dunne and Leopold (1978). Rosgen gives several guides to determining bankfull depth in streams (quotations from Chapter 5 of Rosgen, 1996):

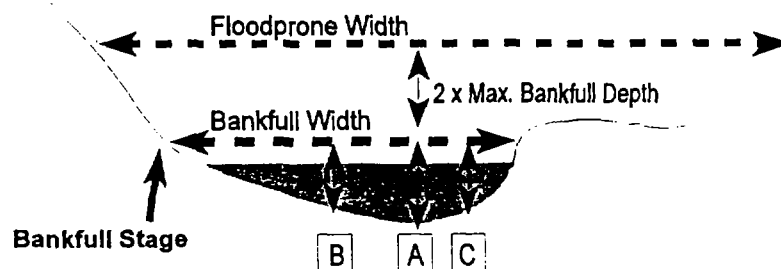
- a. Selected General Principles for the measurement of bankfull characteristics:
 - i. *"Seek indicators in locations appropriate for specific stream types."*
Comment: since the purpose of the headwater habitat evaluation is to survey primarily for biological indicators or to assess specific proposed impacts, site selection often will be constrained to areas of highest quality habitat or because of site specific considerations. Therefore, selection of a site for the determination of bankfull indicators should utilize the most representative portion of the segment of the stream selected for evaluation with respect to the overall characteristics of the stream, taking into account both the upstream and downstream morphological characteristics.
 - ii. *"Know the recent flood and/or drought history of the area to avoid being misled by spurious indicators (e.g., colonization of riparian species within the bankfull channel during drought, or flood debris accumulations caught in willows that have rebounded after flood flows that have receded)."*
 - iii. *"Use multiple-indicators wherever possible for reinforcement of a common stage or elevation."*

b. Visual and Physical Indicators of Bankfull Depth:

- i. *"The presence of a flood plain at the elevation of incipient flooding."*
- ii. *"The elevation associated with the top of the highest depositional features (e.g., point bars, central bars within the active channel)."*
- iii. *"A break in slope of the banks and/or a change in the particle size distribution (since finer material is associated with deposition by overflow, rather than the deposition of coarser material within the active channel)."* Comment: this is often the best key feature for determining bankfull in headwater streams.
- iv. *"Evidence of an innundation feature such as small benches."*
- v. *"Staining of rocks."* Comment: another good feature for use in headwater streams.
- vi. *"Exposed root hairs below an intact soil layer indicating exposure to erosive flow."* Comment: another excellent indicator in headwater streams.

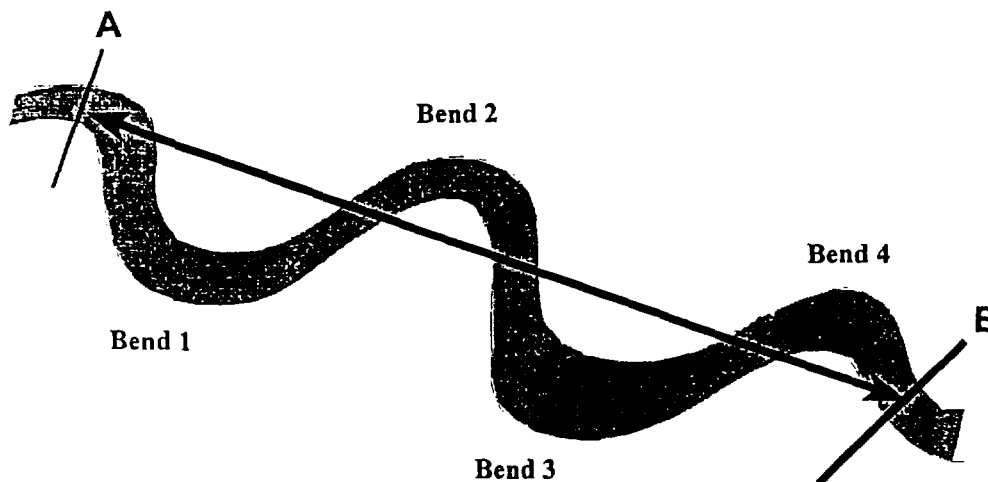
Comment: also of use is the boundary line of terrestrial vegetation along the stream margin. Although caution must be taken under drought conditions (see above), this is an excellent feature to use in combination with other indicators mentioned above for headwater streams.

Figure 1. Calculating Stream Channel Characteristics



A = Maximum Bankfull Depth
 B & C = Bankfull Depth Measurements at 1/2 Distance to Bank From Point A
 Average Bankfull Depth = $(A + B + C)/3$

Figure 2. Sinuosity Measurements



Stream Length = A \longleftrightarrow B

Valley Length = A \longleftrightarrow B

Sinuosity (K) = Stream Length / Valley Length

Often it will be possible to determine the bankfull stage on only one bank of the stream. Therefore, once there is confidence in the bankfull boundary, the measuring string is either held or staked at that point, and the following procedure is used to determine bankfull width (item D1 on check sheet) and the maximum and average bankfull depths (items D2 and D3):

1. Place line level on measuring string.
2. Suspend the measuring string perpendicular to the stream flow from the staked location to the opposite bank.
3. Pull string taut and manipulate up and down until the line level indicates that the string is level. Mark the location where the string intersects the opposite bank. Measure the distance between the marked bankfull locations on either bank of the stream and record as the "Bankfull Width" as item D1 of the check sheet.
4. Using a gage pole or ruler, measure the distance from the string to the stream bottom at the deepest point along the string transect. This measurement is the "Max Bankfull depth" and should be recorded as item D2 of the check sheet and as one of the depths to calculate "Average Bankfull Depth" in item D3 of the check sheet.
5. Again using the gage pole or ruler, measure the distance from the string to the stream bottom at two additional points, each halfway between the point of maximum bankfull depth and the stream bank on either side. Record these values along with the maximum bankfull depth value in the blanks for item D3 and calculate the "Average Bankfull Depth" by taking the average of the three depth measurements. Record the average value in the space indicated.

Note: if measurements are recorded at two locations, record both sets of data on the back of the form and enter the average in items D1, D2 and D3.

Item D4 **Flood Prone Width** (see Fig. 1):

The Flood Prone Width is an estimation of the width of the stream's flood plain. It should not be confused with flood terraces which often border streams, but which are only infrequently inundated. The Flood Prone width is measured with one of the two following methods:

For streams with narrow flood prone areas and minimal obstructions:

1. Disengage the measuring string from its staking for bankfull measurement.
2. With the gage pole positioned the point of maximum bankfull depth, raise the string to the point on the gage pole which is twice the maximum bankfull depth.

3. Extend the string laterally from both margins of the stream, perpendicular to the stream flow to the point where the string line intersects the ground when level and held at the twice bankfull depth location. Mark these points.
4. Measure the distance between the marked points and record as the Flood Prone Width (check sheet item D4)

For streams with wide flood prone areas and obstructing vegetation:

1. With the gage pole positioned in the same location as for the determination of bankfull depth and width, align the sight level at a height equal to twice the bankfull depth.
2. Sight the bank on either side of the stream which is perpendicular to the flow and in line with a level line of sight from the gage pole position, have assistant mark these positions.
3. Measure the distance between the marked points and record as the Flood Prone Width (check sheet item D4)

Notes: 1) if measurements are recorded at two locations, record both on the back of the form and enter the average in item D4. 2) For some streams, the floodprone width can be extremely wide, especially for some channelized streams in wetland areas. In these cases, make a note of this characteristic, but do not take the time to measure the floodprone width.

Item D5 **Valley Length** (see Fig. 2)

The valley length is the straight line distance between two points in mid-channel (or the thalweg) of a defined stream length (see Figure 2). The purpose of measuring the valley length is to provide a standardized measurement of the sinuosity of the stream. To measure valley length, take a straight line measurement with the tape measurer from the upper to the lower marker of the 100 foot zone and record the value as item D5. If two 100 foot zones are used, measure each segment separately, record the valley length for each and enter the average value in item D5.

Item D6, Maximum Pool Depth:

The maximum pool depth within the zone is important since it is a key indicator of whether the stream can support a well balanced fish community. Streams with pools greater than 40 cm (16 inches) in depth are much more likely to have WWH fish communities (Rankin, pers. comm.). Search the zone and record the maximum pool depth observed in item D6.

Item D7. Gradient:

The primary headwater stream being evaluated as part of this program are small and often do not appear on USGS topographic maps. Therefore, mapping procedures cannot be used to determine gradient for the assessment. Gradient for the zone being evaluated should be measured by the following method:

1. Place a gage pole at the water margin at a point even with the marker at the upper end of the zone.
2. Have a fellow crew member place a second gage pole at the water margin even with the marker at the lower end of the 100 foot zone
3. Align the sight level at a known height on the upper gage pole and sight the lower gage pole on a level line of sight.
4. Have the fellow crew member at the lower gage pole raise or lower a hand or object to find the point on the pole even with the level line of sight from the upper pole.
5. Record the difference in height between the height noted on the lower gage pole and the height of the sight level on the upper pole under Item D6. If two 100 foot segments are measured, record both measurements and list the average of the two measurements under Item D7.

Notes: 1) in highly sinuous streams, or where the line of sight is obstructed, it may be necessary to record gradient at several locations and to add the results to get the final gradient for the 100 foot zone. 2) Measurements can also be taken within the channel, however, the gradient must be based upon change in water elevation and not upon change in bottom elevation.

Item D8: Other Modifications

Check and record any of the items listed on the check sheet. For purposes of this item, record only those modifications listed which occur within the zone being evaluated. Similar modifications which are present upstream or downstream of the zone being evaluated which are believed to have a water quality impact should be recorded under Item C6.

Item D9: Sinuosity

Check the appropriate box for the number of complete, well-defined outside bends within the 200 foot zone being evaluated. As an example, the stream segment delineated in Figure 2 would have 4 such bends. The upper curve of the stream at A would be discounted because it is not complete within the zone of interest.

Item D10: Non-point Impacts

Check all non-point impacts listed which might impact the water quality of the stream segment being evaluated. This item should be completed as well as the equivalent assessment on the back of the QHEI form. Any other significant water quality impacts to the stream which are not listed should be described under Item C6.

Section D, Office Calculations:

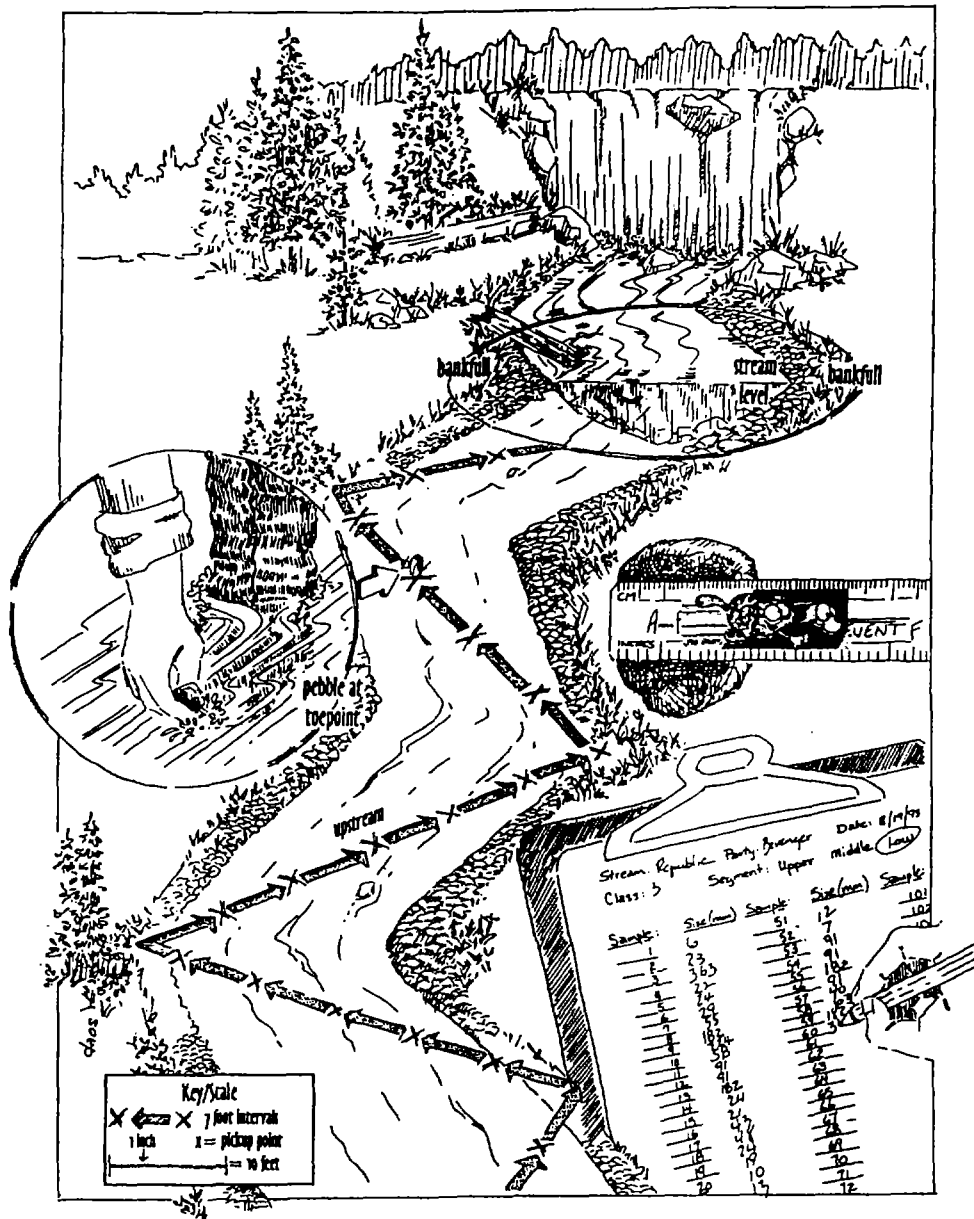
Completion of this section is optional. These values will be calculated when the data is compiled into the computer.

E. Substrate Characteristics:

Next to an adequate supply of water, the substrate characteristics of the stream segment being evaluated are likely to be the most important feature in determining its biological characteristics. In conjunction with other physical characteristics of the stream channel, the composition of the substrate within the stream bed also will determine how the stream exports sediment to downstream water bodies. Therefore, quantification of the substrate characteristics is also an important part of the headwater stream evaluation process.

The procedure used in this assessment is a zig-zag counting method modified from Bevenger and King (1995) (see Figure 3). In order to quantify the substrate, a zig-zag path is walked going from bankfull to bankfull throughout the 100 foot zone. According to a pre-determined pattern, substrate is evaluated and measured, if necessary, from the upstream to the downstream marker point in the zone (e.g., every third step, the substrate at the big toe of the left foot is evaluated). Measurements are called out to a data recorder, who then tallies the observation on the data sheet according to the size category of the pebble or the type of substrate encountered. The evaluator (i.e. the person walking the stream) should note whether the substrate is in the dry or wetted channel, from a riffle or pool, and the size (in mm) of the substrate particle along the

Figure 3. Zig-zag method for conducting pebble counts. (From Bevinger and King, 1995).



intermediate axis of the particle (e.g. for a "pebble" 260 mm long, 50 mm deep, and 150 mm wide, the 150 mm dimension would be used and it would be classified as "large cobble"). Silt, clay hardpan, bedrock, and detritus, when found, are tallied without the need for measurement.

The definition for fine particles in this evaluation are the same as those used in conducting QHEI's (Rankin, 1989). Sand has a gritty texture when rubbed between the fingers, while silt is finer (0.004-0.06 mm) and feels greasy when rubbed between the fingers. Clay hardpan forms a dense gummy surface which is difficult to penetrate. Detritus consists of dead, unconsolidated organic material which includes leaves, sticks, wood and other partially decayed coarse plant material.

The zone should be walked so that a minimum of 40 observations are made within the wetted channel. There are no minimum number of observations needed from the dry channel, since for many small streams, the dry channel at the stream margin will be quite small (what you get is what you get). However, if a sufficient number of observations are made in the dry channel (i.e. 40-50) prior to completion of the wetted channel evaluation (note: this is very unlikely), further evaluations in the dry portion of the bankfull channel are not necessary. The evaluation of the wetted channel can then be completed more quickly.

Data for the "Total Wetted Channel", "Percent Wetted Channel" and "Percent Cumulative" data columns do not need to be calculated in the field.

Sections F., G., H., and I. (page 5):

Enter the appropriate information for these sections of the check sheet. For Section H, be sure to record any unusual circumstances or deviations from the sampling protocol which may have occurred during the assessment.

Section J. (Page 5):

Circle yes or no as to whether enough fine sediment occurred at the site for the collection of a valid sediment sample. This information may be used to determine appropriate sites for subsequent headwater reference site sediment sampling.

Section K. Biological Characteristics:

1. Headwater Fish (page 6):

Some primary headwater streams may contain fish species, since there is a gradual continuum in nature where salamanders replace fish as the top level vertebrate predator in natural watersheds. Also, there are many areas in northwest and west central Ohio from which stream salamanders are not known to exist due to the flat, swampy physiography of that area of the state. Thus it is possible that some primary headwater habitat streams that by definition are less than one square mile drainage area will contain only fish as the top level vertebrate predator.

If fish are observed in the stream they should be collected using a small 10 foot seine. A fine mesh benthic invertebrate net can also be used. Collect fish for at least 15 minutes through the 100-200 foot section of stream under investigation. Record all species collected and their total numbers on the field form. Voucher specimens should be collected for each species and preserved in a solution consisting of one part buffered formalin and nine parts water. Place a field tag in/on the jar which includes date, collector name, county, township, and stream identification as listed on the field evaluation form. Record total time spent searching for fish on the field form.

Notes: 1) If voucher specimens are to be held longer than 2-3 weeks, the specimens should be transferred to an alcohol preservative using the methods described in the Ohio EPA methods manual (Ohio EPA, 1989). 2) If there are deep pools present that are greater than 40 cm maximum depth the Ohio EPA QHEI habitat evaluation should be conducted and the stream evaluated for potential to attain the Ohio EPA Warm Water Habitat (WWH) biological criteria according to established agency procedures (Rankin, 1989).

1. Stream Salamanders (page 6):

For primary headwater streams, of particular interest is the presence of larvae or egg masses of any of the following salamander genera *Eurycea*, *Gyrinophilus*, *Pseudotriton*, or the species *Ambystoma (texanum) barbouri* (Storfer, 1999), the stream breeding variation of the smallmouth salamander. This group of salamander genera in Ohio have aquatic egg-laying habits and the larval stage may last from 1 to 4 years. These amphibians replace fish as the top level vertebrate predator in undisturbed small primary headwater streams in Ohio.

The presence of larvae or egg-masses in the stream is direct evidence that the aquatic habitat is important to the long term growth and development of the native fauna, and that the stream is being used to support a reproducing population of vertebrates on an annual basis. Juvenile or adult salamanders alone, without larvae or egg-masses, cannot be used as conclusive evidence

that the stream under investigation is important for growth and reproduction of a population, because it is possible for transformed salamanders to migrate into ephemeral streams but not reproduce. Adults can be used to help verify the taxonomy of the salamander species present. Evidence of the stream-side salamander *Desmognathus* species (e.g., Mountain Dusky and Dusky Salamanders) is less telling because the larval period of Dusky salamanders is less than one year and populations can exist in small streams that dry-up in the summer months.

A. Salamander Sampling Effort (10 m Stream Length)

The goal of the salamander evaluation to be used in the headwater habitat assessment is to document the presence-absence of a reproducing population of salamanders, and not to estimate salamander abundances on a unit area basis. Although this method is semi-quantitative, more vigorous sampling techniques must be utilized to quantify salamander densities for empirical comparisons (see Rocco, 1997 for a 4 m² quantitative sampling method).

Begin the survey by selecting a 10 m section of stream that has optimal number and size of cobble type microhabitat substrate (64 to 128 mm length). The salamander survey zone should be near the upper end of the total 100-200 foot section of stream under investigation. An ordinary tea strainer, bent to a triangular shape, or a fine mesh aquatic invertebrate net is recommended to collect salamanders, especially the small slippery and elusive larvae. Due to high oxygen demand, gilled, premetamorphic larvae are restricted to the flowing water of the stream. They are often found hiding under cover objects such as rocks, leaves, and woody material as a protection from possible predators. As you move upstream, first place the net against the bottom substrate and then lift cover objects in front of the net. To capture larval salamanders, position the net front of the salamander's head, and gently touch the tail; more often than not they will move forward into the strainer. Replace cover objects that are lifted to their original position to minimize habitat disturbance. An attempt should be made to capture all salamanders observed. A high intensity head light may be helpful in some headwater streams due to low light conditions under tree canopy.

All captured salamanders should be placed into a plastic container so that species can be identified and the total number of each type counted. Take note of any salamanders that escape capture.

Place all captured salamanders into a white tray with a small amount of water. Gills on the head of the larvae will be visible to allow them to be identified. Record the total number of each salamander species collected, and the total number of salamanders observed but that escaped capture (see Attachment 1). After voucher specimens are taken

(see Section C below), replace all remaining salamanders into the 10 m zone from which they were collected.

Remember that the goal of the sampling effort is to document the presence-absence of a reproducing population, thus all available micro habitats should be searched to ensure that a proper decision is being made. At least 30 minutes should be spent searching for salamanders, and the entire 10 m zone should be surveyed during the survey. However, if a significant number of larval salamanders have been collected after a 30 minute sampling effort and the entire 10 m zone has not been completed, you may stop the survey and record in meters the total length of stream surveyed.

Within each 10 m zone, salamander abundance is estimated using the Visual Encounter Survey (VES) technique as described by Heyer et al. (1994). Time is expressed as the number of person-hours of searching within the 10 m stream segment. At least 30 minutes should be spent searching within each 10 m zone. Record exact time to the minute on the field assessment sheet. A VES can be used to determine the salamander species richness of a stream segment and to estimate the relative abundances of species on a time basis. Because turbidity can greatly effect the results of a VES, monitoring should only be conducted when water is clear.

B. Salamander Voucher Specimens

Collect voucher specimens and transport live to the laboratory for proper preservation. Place captured salamanders into plastic bags with some moist leaf litter or moss, place in a cooler with block ice for transport to the lab for preparation of scientific voucher specimens. At least two larvae and two juvenile-adults for each species should be preserved for each species if possible. At the lab, salamanders should be killed as quickly and humanely as possible in a way that leaves them in a relaxed position. Salamanders may be killed by drowning in warm water (43-47 degrees C), or in a weak alcohol (15%-25%) solution. It may be necessary to straighten the organism several times prior to death in order to ensure that they are not fixed in a curled position. Once dead, the specimen is fixed by placing in a tray lined with white paper towel soaked with 10% formalin. The individual should be laid out straight with the limbs pointing forward parallel to the body. The toes should be spread with the palmar surface facing down. Cover with a second paper towel and add 10% formalin to the tray to a depth of 1 cm. Cover the tray to stop formalin odors. The salamanders should harden somewhat within 2 hours. Specimens should then be transferred to a jar of 10% formalin for shipment. Place a field tag in/on the jar which includes date, collector name, county, township, and stream identification as listed on the field evaluation form.

3. Benthic Macroinvertebrates (pages 7 and 8):

After sampling for salamanders and fish is completed, collect benthic macroinvertebrates using standard qualitative kick-net methods (Ohio EPA, 1989). Sample all available habitat types within the 100-200 foot stream segment such as riffles, runs, and along stream margins. Collect invertebrates for at least 30 minutes throughout the stream and thereafter until no new taxa are found. Use the field form (Attachment 1) to record the presence and relative abundance (i.e., rare, common, abundant) of all taxa collected within the sampling area. Voucher specimens of all taxa should be collected and preserved in 95% ethanol. Special effort should be made to collect specimens of all potential EPT (i.e., mayflies, stoneflies, caddisflies) types to allow for potential future calculation of Total Qualitative EPT Taxa. Place a field tag in/on the jar which includes date, collector name, county, township, and stream identification as listed on the field evaluation form.

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Attachment 1. Ohio EPA Primary Headwater Habitat Evaluation Form

Evaluation Date: _____ Evaluator(s) _____

Site Name: _____ District/Unit: _____

C. STREAM INFORMATION:

1. County: _____ 2. Township/City: _____

3. NRCS MapPage: _____ (Attach copy, mark stream) 4. USGS Topo: _____

5. Location Information: _____

6. Ecoregion (circle): EOLP HELP ECBP WAP 7. Watershed area _____ mi²

8. Latitude: _____ Longitude: _____ Source (circle): GPS / Map

9. Estimated Date of Last Precipitation _____ Quantity: (inches) _____

10. Photos taken? Y / N

D. RIPARIAN ZONE INFORMATION:

Time Spent (minutes): _____

1. Riparian Soil Types: (three most dominant, use soil map abbreviations)

2. Canopy: (percent open)

100% ☐ 75-99% ☐ 50-74% ☐ 25-49% ☐ 0-24% ☐

3. Dominant trees present:

4. Dominant shrubs/undergrowth:

D. STREAM CHANNEL CHARACTERISTICS:

Time Spent (minutes): _____

1. Bankfull Width: Seg #1 _____ Seg #2 _____ Units (circle): Feet / Meters

2. Max. Bankfull Depth: Seg #1 _____ Seg #2 _____ Units: _____

3. Bankfull Depth Measurements:

Seg#1: 1 _____ 2 _____ 3 _____ Average: _____ Units: _____
(Max. Bankfull Depth)Seg#2: 1 _____ 2 _____ 3 _____ Average: _____ Units: _____
(Max. Bankfull Depth)

4. Flood Prone Width: Seg #1 _____ Seg #2 _____ Units (circle): Feet / Meters

5. Valley Length (feet/100 ft of stream) : Seg #1 _____ Seg #2 _____ Avg _____

6. Max pool depth (within 200 foot zone): _____ Units (circle): Inches / Centimeters

7. Gradient (ft/100 ft.): Segment #1 _____ Segment #2 _____ Average _____

8. Other Modifications: (check all that apply)

Culverts ☐ Number _____ Footage _____Storm Drain Outlets ☐ Number _____ Size _____Drain Tile Outlets ☐ Number _____

9. Sinuosity (number of outside bends in 200 foot zone).

None (straight channel) ☐ 2 ☐ 4 ☐1 (or poorly defined) ☐ 3 ☐ more than 4 ☐

10. Non-Point Impacts: (check all which potentially impact stream segment)

On-site Sewage Systems ☐ Agricultural Runoff ☐ Urban/Residential Runoff ☐Industrial Site Runoff ☐ Waste Disposal Site ☐ Construction Runoff ☐

D. STREAM CHANNEL CHARACTERISTICS: (cont.)

Office Calculations:

Slope (ft/ft) = Average Gradient (ft/100ft) _____ ÷ 100 ft = _____

Entrenchment = Flood Prone Width _____ ÷ Bankfull Width _____ = _____

Sinuosity (K) = Stream Length (100 ft) ÷ Average Valley Length (ft) _____ = _____

Width:Depth = Bankfull width _____ ÷ Average Bankfull Depth _____ = _____

Rosgen Classification: _____

Notes re: Rosgen Classification:

E. SUBSTRATE CHARACTERISTICS:**1. Zig-Zag Pebble Count Results:**

Time Spent (minutes): _____

Particle Size (mm)	Dry Channel	Wetted Channel		Total Wetted Channel	Percent Wetted Channel	Percent Cumulative
		Riffle	Pool			
Bedrock						
Boulder >256 mm						
Large Cobble (129-256 mm)						
Small Cobble (65-128 mm)						
V. Coarse Gravel (33-64 mm)						
Coarse Gravel (17-32 mm)						
Med. Gravel (9-16 mm)						
Fine Gravel (5-8 mm)						
V Fine Gravel (2-4 mm)						
Sand (<2 mm)						
Silt						
Clay Hardpan						
Detritus/ Woody Debris						
Column Total						

2. Comments re: Substrate:

Office Calculations:

Total Counts Made (wetted channel) _____

Percentages for Substrate Types: (number counted for each substrate / Total Counts x 100)

Bedrock	_____
Boulder	_____
Cobble	_____
Gravel	_____
Sand	_____
Silt/Clay	_____
Detritus/ Woody Debris	_____

F. **QHEI SCORING** (attach completed QHEI scoring sheet for the site).

QHEI score for stream segment _____

G. **SUBJECTIVE RATING OF STREAM SEGMENT:**

1. Biological Quality (1-10): _____

2. Aesthetic Quality (1-10): _____

H. **COMMENTS:** Please list any other comments regarding the site, sampling results or methodology in the space below:

II. Total time spent at site: _____ minutes

J. Did the site have depositional areas of fine sediments which would provide a valid sample for the evaluation of sediment chemistry?

Y / N (circle appropriate response)

K. **BIOLOGICAL CHARACTERISTICS:**

1. Fish: Voucher Specimens Retained? (circle) Y / N Time Spent (minutes): _____

Species	Number Caught	Notes

2. Salamanders: Voucher Specimens Retained? (circle) Y / N Time Spent (minutes): _____

Stream length assessed (meters) _____

Species	Larvae	Juveniles/Adults	Total
Dusky (<i>Desmognathus</i>)			
Two-Lined (<i>Eurycea</i>)			
Mud (<i>Pseudotriton</i>)			
Red (<i>Pseudotriton</i>)			
Long-tailed (<i>Eurycea</i>)			
Small Mouthed (<i>Ambystoma</i>)			
Spring (<i>Gyrinophilus</i>)			
Other (name)			
Total			

3. Notes on Vertebrates:

3. Macroinvertebrates: indicate abundance of macroinvertebrate taxa. For EPT taxa, also indicate the number of different taxa present.

Key: V=Very Abundant (>50), A=Abundant (10-50), C=Common (3-9), R=Rare (<3)

Porifera (sponges) _____	Hemiptera (bugs) _____	Gastropoda (snails) _____
Hydrozoa _____	Sialidae (alderfly) _____	Bivalvia (clams, mussels) _____
Turbellaria (flat worms) _____	Corydalidae (dobsonflies) _____	
Bryozoa _____	Coleoptera (beetles) _____	<u>EPT Taxa</u>
Oligochaeta (segmented worms) _____	Tipulidae (crane flies) _____	Ephemeroptera (mayflies) _____
Hirudinea (leeches) _____	Culicidae (mosquitoes) _____	# of taxa _____
Isopoda (sow bugs) _____	Simuliidae (black flies) _____	Plecoptera (stoneflies) _____
Amphipoda (scuds) _____	Ceratopogonidae (biting midges) _____	# of taxa _____
Decapoda (crayfish) _____	Chironomidae (red types) _____	Trichoptera (caddisflies) _____
Zygoptera (damselflies) _____	Chironomidae (non-red) _____	# of taxa _____
Anisoptera (dragonflies) _____	Other Diptera (flies, e.g. Tabanidae, etc.) _____	Total EPT taxa _____

Voucher Sample ID _____

Time Spent (minutes): _____

Notes on Macro-invertebrates:

Riffle:

Predominant Organisms: _____

Other Common Organisms: _____

Diversity: High _____ Moderate _____ Low _____

Pool or Glide:

Predominant Organisms: _____

Other Common Organisms: _____

Diversity: High _____ Moderate _____ Low _____

Other Notes: _____

Primary Headwater Habitat Evaluation

Attachment 2: Field Check List for Headwater Habitat Sampling

Physical-Chemical Sampling:

- ☐ Attachment 1 field data form from HWH manual with clip board, pencil
- ☐ 100 foot tape measure, cloth
- ☐ 100 foot heavy nylon red string on spool
- ☐ line bubble level
- ☐ sight bubble level
- ☐ ruler (in cm)
- ☐ 2 surveyor rods (or one rod and a second pole marked in feet)
- ☐ 2 color flag markers (to mark ends of sample zone)
- ☐ stop watch
- ☐ plastic float (i.e., fishing bobber)
- ☐ camera
- ☐ film for camera
- ☐ clip board, pencils
- ☐ carry bag
- ☐ chemical meters (dissolved oxygen, temperature, pH, conductivity)
- ☐ Two qt. cubi containers for potential water samples for nutrients and metals
- ☐ Mosquito repellent
- ☐ Optional: GPS unit for lat./long.

Biological Sampling:

- ☐ hip waders or chest waders (knee boots not recommended)
- ☐ fine mesh kick net for invertebrate sampling
- ☐ white sorting pans (2)
- ☐ fine tip forceps
- ☐ specimen jars: 95% alcohol for invertebrates, and formalin solution for fish voucher samples
- ☐ large tea strainer or fine mesh small handle invertebrate net for salamanders
- ☐ hard plastic container with air holes in lid for salamander collection
- ☐ heavy duty plastic bags (4) for transport of salamanders to lab
- ☐ small cooler with ice or block ice for salamander transport and water samples
- ☐ marker flags (2) to mark ends of sample zone
- ☐ 10 meter line to measure length of sample zone
- ☐ 10 foot fish seine
- ☐ Optional: High intensity head lamp

DRAWINGS